SEA-AIR INTERMODAL PORT PAIR SELECTION CRITERIA IN SOUTH AMERICA

GRADUATE RESEARCH PAPER

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Abstract

Intermodal operations have been crucial to the success of recent TRANSCOM distribution actions across the globe. Understanding the most appropriate factors to consider in seaport and airfield transloading pairs is critical to efficient and effective use of the intermodal option. TRANSCOM utilizes an analytic heuristic process within an intermodal seaport and airfield suitability model to rank order capability ratings of transloading sites. This research identifies the most important criteria for evaluating intermodal transloading pairs by a thorough review of scholarly literature, multiple runs of the TRANSCOM suitability model, and comparative assessment of various trial results. This analysis was then used to identify the most capable seaport and airfield pairs in South America for military or humanitarian assistance/disaster relief actions supported by intermodal distribution operations. While effective in its current form, the TRANSCOM suitability model may be more informative for planning by incorporating criteria for port pair reliability. The paper proposes that appropriately evaluating accessibility, capability, timeliness, security, and reliability as service characteristics for transport offers the best criteria for evaluating theater intermodal transloading locations. The research also considers factors outside the TRANSCOM model to incorporate the Failed States Index's measure of national stability as a proxy for reliability.

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Phillip A. Shea

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I. Introduction

Background, Motivation, and Problem Statement

Recent deployments have shown the utility of intermodal transport options to quickly and efficiently move large force package rotations in support of geographic combatant commanders' requirements (USTC, 2009). Selecting the best ports for transloading from sea to air is critical in executing that mission. United States Transportation Command (TRANSCOM) has used an Analytic Hierarchy Process (AHP) which evaluates ten seaport and airfield factors to prioritize port pairs in a number of geographical combatant commands' area of responsibility (AOR). Recent humanitarian assistance/disaster relief operations in Haiti highlighted United States Southern Command's (SOUTHCOM) need for fresh logistical planning. Identifying factors and data sources to broaden the scope of the existing model can help TRANSCOM remain flexible in supporting worldwide combatant commanders.

This GRP utilizes TRANSCOM's port selection model to identify the best seaport and airfield pairs for intermodal transloading during possible contingencies in SOUTHCOM's AOR. The existing TRANSCOM model also relies on AHP to give priority ratings to single criterion; giving more proportional value to criterion identified as most important to the planners compared to other factors under consideration. This research proposes that process may not be required. Additionally, this research proposes new factors based on a review of port selection literature that may be addressed within the model to include political stability or theater and country reliability considerations. Finally, by re-accomplishing the model execution with differing factors incorporated, the research analyzes any difference in port pairs determined by the different methods.

The on-going focus of combat activities in United States Central Command (CENTCOM), the specter of a rising peer competitor in United States Pacific Command (PACOM), and the recent lack of major conflicts within its AOR highlight the recent lack of focus on SOUTHCOM. The great ability to respond in crisis, as evidenced by the Haitian earthquake response, shows SOUTHCOM's flexibility and its focus on Building Partnership Capacity. However, the current forward operating locations actively use in Latin-America may not be the most capable for supporting large-scale intermodal operations. Additionally, their locations in the northern tier of the AOR may not be optimal for full coverage of South America (USSC, 2011). It is vital to study strategic locations within the theater outside those currently in use. This study can provide context for intermodal operational planning in SOUTHCOM and the theories developed can be incorporated across multiple geographic combatant commands.

Research Focus

This research focuses on the SOUTHCOM AOR and examines relatively long-lead time operations which can take greatest advantage of sea-air intermodal transport. Efficient intermodal strategic transport utilizing sea and air legs requires a reasonable amount of lead-time for its gains to be realized. Long-lead operations within SOUTHCOM's vision for the next ten years include HADR for large scale emergencies, as shown by the earthquakes of 2010 in Haiti and Chile, on-going counter illicit trafficking, and peace keeping operations. Each of the preceding mission areas tie into SOUTHCOM's overarching AOR strategy (USSC, 2010). In a broader planning context, contingency responses requiring large or sustained quantities of cargo best suited to intermodal transport would also benefit from the focus of this research. The crux of this study is not to re-create or develop a new model for analyzing port pairs, but to build on the existing TRANSCOM suitability model and make recommendations for other possible factors or relative weightings to sharpen the effects of the current model.

Research Objectives/Research Questions & Hypotheses

This study attempts to answer the question, what are the best seaport and airfield pairs in the SOUTHCOM AOR for intermodal transloading? The researcher hypothesizes that significant factors, beyond those currently utilized by TRANSCOM planners, should be considered. Those factors may include host-nation, theater stability or reliability constraints in port pair analysis. The inclusion of these additional factors may have a significant impact on selection preference for port pairs. This hypothesis poses additional topics addressed in this research to include:

1. What are the most appropriate factors to consider for selection preference of operationally effective port pairs?
2. Are the weighting factors utilized by TRANSCOM effective in determining best seaport and airfield pairs?
3. What factors, different from those already in use by TRANSCOM, can be identified to evaluate seaport and airfield pairs for intermodal transloading?

4. By using newly selected criteria to modify the TRANSCOM model, how does the best seaport and airfield pair selection differ?

Theoretical Lens

There is a significant body of work on mode selection and network analysis in both supply chain management and logistics network theory. Selection preference theory can provide insight on motivation and justification for factor identification. This study draws on the best of these fields for military operational feasibility and applies them to the SOUTHCOM AOR for the seaport and airfield transloading node in intermodal operations. The nature of the proposed research is qualitative with elements of quantitative data. There is the use an AHP model for selection preference.

Methodology

The research determines what seaport and airfield pairs are best suited for intermodal transloading operations in the SOUTHCOM AOR. It considers suitable port pairs in the SOUTHCOM AOR that may be utilized and rank them via the existing TRANSCOM model. Then, the newly identified categorical factors are incorporated into the model for comparison of the results. An analysis of the differences in the results allows a comparison of the impact of comparative factors within the models; though much of the data is static based on the nature of the infrastructure requirements for strategic seaports and airfields.

The researcher utilizes the existing AHP model from TRANSCOM Joint Distribution Process Analysis Center (JDPAC). The existing suitability model uses ten “easy to measure” factors to provide and rank a suitability score to seaport and airfield pairs. It was developed in response to a short-notice tasking for CENTCOM and has been utilized for PACOM exercise planning (Erspamer, 2010). Specific data for use in selection and AHP modeling was obtained from IRRIS (Intelligent Road/Rail Information System), Air Mobility Command's ASRR (Airfield Suitability and Restrictions Report), TRANSCOM JDPAC, Transportation Engineering Agency assessments, the 832nd Transportation Battalion port studies, and other open-source databases.

Assumptions/Limitations

The research requires a number of basic assumptions. First, that military strategic lift is a realistic means of building partnership and has strategic influence in the subject AOR. Secondly, that Focused Logistics remains a key tenet of force projection for HADR and military operations as outlined in *Joint Vision 2020* (CJCS, 2000). Third, that the quantitative data available for port analysis is accurate and actionable with respect to the categories of interest, and that the ports identified are suitable for use. Finally, that there exists a means of quantifying political, stability or country and theater reliability considerations with effective correlation for use in the selection model.

There are also important limitations to which the research is subject. The study does not reassess existing port pairs in use for CENTCOM, PACOM, or United States European Command. No analysis on buildup/improvement/maintenance of capacity or capability at existing facilities is incorporated. Additionally, the research does not address costs (time/money/operational) associated for actual transport (i.e. shipping distances or air distances)—this area is best covered in additional research; it is assumed that the timeline allows sufficient planning and spin-up time to negate differences in sea-steaming time. The study avoids any use of classified data. This results in the use of notional data in regard to security ratings. The study is limited to a usability analysis and not timeliness or actual political feasibility (i.e. will a country allow US operations when and where it desires). Those factors vary depending upon the actual operational scenario and issues.

Implications

The results of this research will have immediate impact on future planning and operations for SOUTHCOM. Currently, SOUTHCOM's focus on Building Partnership Capacity and political-military relations does not exclude the need for the type of planning accomplished in this study. CENTCOM, PACOM, and United States European Command have extensive experience and well utilized port pairs, but as political and operational climates change, further analysis of useful intermodal port pairs may be required. The factors identified in this research can offer additional insight or comparative differences from previous planning/use models for use in any geographic combatant command. Ultimately, in identifying new factors, the existing TRANSCOM suitability model can be improved and usability in future applications be increased.

Overview

The remainder of the GRP outlines what port pair selection criteria should be examined for sea-air transloading in SOUTHCOM. The Chapter II literature review examines relevant literature and associates the findings with the research questions posed above. Chapter III defines the methodology of the analyzing SOUTHCOM port pairings with respect to the existing AHP model, data acquisition, as well as modifications of adding new criteria to the model. Chapter IV summarizes the results of the new model trials compared to original analysis. Finally, Chapter V presents conclusions, recommendations, and areas for future study.

II. Literature Review

There are important parallels between business and military mobility application of intermodal transport theory that will benefit today's logisticians. There are vast amounts of literature on intermodal operations in the civilian sector, but its parallels to military operations are less prevalent in scholarly works. Unfortunately, there is a relative dearth of literature on the case considered in this GRP: the sealift to airlift intermodal transition (Raguraman and Chan, 1994). While the sea-air mode selection is not exclusive to military operations, there is far less written that examines the relative importance of selection criteria in that realm and its relation and impact on military effectiveness. This literature review provides a background to US military intermodal operations in the recent past; describes a background of the AHP method; identifies common selection criteria for intermodal node selection; and finally, covers geo-political context in the Failed States Index that can provide additional relevance to the TRANSCOM port selection model.

Raguraman and Chan note (1994) that the sea-air transportation mix creates, as a compromise between the two long-distance modes of transportation, benefits in cost savings and time savings compared to single mode usage. They describe the best candidates for these movements to be of medium to high-value goods and should be moderately time-sensitive, based on the speed of the air leg. They also highlight that the majority of sea-air cargo has been downgraded from straight airlift. Current operations reveal this in the following discussion of recent military sea-air intermodal operations.

Recent US Intermodal Operations

The United States military has always utilized intermodal transport to get its forces to the fight. The following section addresses a brief background of intermodal military mobility operations and highlights some of the successes and lessons learned in operations since 2006. The researcher chose to consider this more recent timeframe as it revealed a marked transition from relative single-mode movements (all sea or all air) to the sealift-airlift intermodal solution recognized as being both effective and cost efficient.

Military intermodal operations consist of the transferring of passengers or transshipping of cargo among two or more modes of transportation (sea, highway, rail, and air) (CJCS, 2010). Nearly all cargo can be considered intermodal depending on the lens and scope of examination. The choice between transport by exclusively one mode, be it surface via rail, sea, or truck, or by air from behind the lines to the frontlines is often dictated by the geography, location of friendly forces, and location of hostilities. This research considers the global nature and scope of regional and international military operations.

Additionally, the terms “multimodal” and “intermodal” are found in various use throughout commercial, joint, and service literature. Previous editions of TRANSCOM’s Annual Report defined a difference in the terms (USTC, 2001), but versions subsequent to the 2001 edition dropped the definitions and the terms are not specifically defined in joint doctrine. This examination considers multimodal and intermodal interchangeable, but for convention, utilizes the term intermodal.

There is a history of intermodal operations spanning from World War II and the great arsenal of democracy in North America, producing and transporting goods worldwide by sea, rail, and road, through today's operations in the landlocked country of Afghanistan. A military logistician could take advantage of cost, time, capability, and security benefits of specific modes of transport by utilizing varying modes of transport (Coyle, 2011). Sealift's strength in bulk, cost, and capability can offset the speed and security strengths inherent in airlift. Coyle also highlights these as important service criteria which are significant to criteria determination in transload port selection discussed later.

United States' forces have transitioned from a pre-positioned global garrison force to an expeditionary focused force that relies on its ability to rapidly deploy large forces through the strength of its mobility system. The mobility and distribution system that enables this expeditionary nature is managed through TRANSCOM. As the Distribution Process Owner (DPO) it is "responsible for coordinating and overseeing the DOD [Department of Defense] distribution system to provide interoperability, synchronization, and alignment of DOD-wide, end-to-end distribution" (CJCS, 2010: xix). Moving units from their home stations to the front has entailed intermodal operations in nearly all its forms: passengers via air to aerial ports of debarkation (APOD), to airlift of mission critical assets from the continental United States to APODs and then convoying via ground to a forward operating base (FOB), as well as sealift from seaports of debarkation and airlift or ground transport to the front. "Focused Logistics" is a complex ballet that must take into account what, where, when, and how America's war materials need to be moved to ensure mission success (CJCS, 2000).

The key for military mobility is knowing when and how to use the correct intermodal solution. While the US was experienced in the technique, once again it was a hard lesson learned after years at war for TRANSCOM to switch to “smart” intermodal operations. TRANSCOM Commander, General Duncan McNabb, highlighted recent successes in intermodal operations and revealed tremendous savings in both time and money by using the right combination of both air and sealift (2010). The continuing nature of the operations in Iraq and Afghanistan should have easily signaled the need to use intermodal operations, but TRANSCOM did not utilize intermodal operations for force rotation movements, or realize those efficiency gains in cost and time, until 2006 when it shipped helicopters and aviation equipment to Spain for transloading for airlift into theater (Brigham, 2007). The following section briefly describes some of the large scale successes in intermodal operations since 2006 and cover some of the challenges that are present for the military transport mission in conducting these operations.

As discussed earlier, the military utilized intermodal transport since World War II to move its forces overseas. In his book on the logistics experiences of Desert Storm, Lieutenant General William G. Pagonis, the director of logistics for Desert Storm, shows some of the relative differences in how the intermodal movement of US forces has changed. Figure 1 below shows the relative buildup of forces, and also what would then need to be redeployed, but doesn’t show the rotational nature of today’s force structures in use for Iraq and Afghanistan.

ARMY DEPLOYMENT COMPARISONS	WWII 7 Dec 41	Korea 1950	Vietnam 1965	Saudi Arabia 1990
FIRST 30 DAYS		–	–	–
Passengers Shipped To Theater	29,839 Most by ship			
Passengers Airlifted To Theater		11,990 Aug	16,300	38,083
Tons of Supplies & Equipment Shipped	–	76,965 July	–	123,590
Tons of Supplies & Equipment Airlifted	–	–	–	39,991
FIRST 60 DAYS				
Passengers Shipped To Theater	91,045 Most by ship	–	–	1,039
Passengers Airlifted To Theater		22,716	85,563	106,000
Tons of Supplies & Equipment Shipped	560,160 Most by ship	400,437	1.2 million	400,000
Tons of Supplies & Equipment Airlifted		–	38,564	106,000
FIRST 90 DAYS				
Passengers Shipped To Theater	138,424 Most by ship	–	82,800	1,453
Passengers Airlifted To Theater		32,357	85,562	183,030
Tons of Supplies & Equipment Shipped	836,060	979,833	1.3 million	1,071,317
Tons of Supplies & Equipment Airlifted	–	–	38,564	175,668

Figure 1 – Army Deployment Comparisons
(Pagonis, 1992: Table 1-1)

The mobility mission in today's fight for the US military is significantly different from the past. Current overseas operations have gone on longer than any of the conflicts noted by Pagonis. And instead of units being in the fight for the duration, the US has conducted surges, withdrawals, and scheduled major unit force rotations. For units deploying to the fight for a third and fourth time, speed was desired and the air choice for equipment and personnel negated many intermodal considerations.

The concept in use today is to take advantage of intermodality, where possible, to move the required equipment faster and cheaper. Specific examples in use to support the fight in Afghanistan involve helicopter force rotations, the deployment of highly mobile Stryker brigades, and the insertion of force protection Mine-Resistant Ambush-Protected (MRAP) vehicles and MRAP All-Terrain Vehicles (M-ATV). As described earlier, General McNabb showed that TRANSCOM could close the deployment timeline faster and cheaper by shipping, transloading, and then airlifting to the final destination than attempting to airlift the entire force from the Continental US to Afghanistan. The following figure displays the focus of TRANSCOM's and CENTCOM's intermodal transloading hubs for these moves.

Figure 2 displays TRANSCOM's planned and current intermodal locations: Diego Garcia, Rota, Bahrain, Oman, and United Arab Emirates (UAE). It is informative to discuss each node and some benefits and drawbacks of the successful operations there. Using the seaport-airfield hub at Rota for helicopters moves, which began the utilization of transloading intermodal ports for force rotations, has previously been described. The successes and issues related to the other locations will follow.

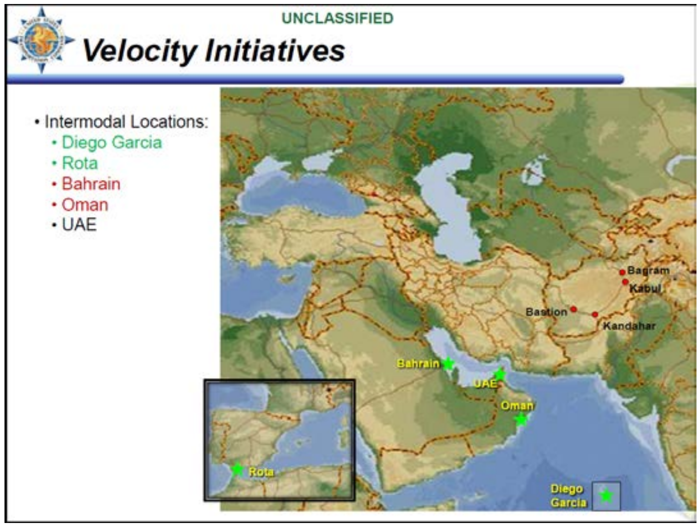

Figure 2 – USTRANSCOM Intermodal Locations
(USTC, Operations Update, 2010: 11)

Diego Garcia, British Indian Ocean Territory, was the sight of one of TRANSCOM's greatest successes in intermodal operations and also acted as a proof of concept for the Joint Task Force-Port Opening (JTF-PO) concept. In 2009, Operation ISLAND STRYKER accomplished the insertion of the 5th Brigade, 2nd Infantry Division (Stryker Brigade Combat Team) from Fort Lewis, Washington, into Afghanistan. The vehicles and majority of equipment were sealifted to Diego Garcia, marshaled at the port, prepped for airlift, and then airlifted to the theater. According to TRANSCOM's after action report, "combining sealift and airlift capability at intermodal sites allow[ed] USTRANSCOM to increase velocity, decrease delivery times and save money simultaneously" (USTC, 2009: 7). Advantages at Diego Garcia included collocation of port and airfield, and a friendly coalition ally owning the territory for access. Diego Garcia's greatest disadvantage was in transit time due to location. While imminently capable and secure, it was the furthest from the theater for both sea and airlift.

Two relatively new locations that TRANSCOM utilized for intermodal operations were Bahrain and Oman. Each of these were utilized in 2010 in response to President Barack Obama's troop surge in Afghanistan. CENTCOM's need for M-ATVs in a landlocked country posed a tremendous challenge to TRANSCOM. With a requirement of over 1,000 combat vehicles per month (McNabb, 2010), TRANSCOM found two locations in Bahrain and Oman to sealift the vehicles, transload to air, and then airlift to the frontlines in Afghanistan. The issues with respect to capability and security service characteristics provided challenges.

In Bahrain, host nation concerns prevented M-ATVs that were sealifted from being moved from the seaport to the airfield during daylight hours. Had the seaport and airfield been collocated, this may not have been an issue, but transport truckload convoys could only depart the seaport between the hours of midnight and 3AM for the 25 mile journey. This restriction affected daily throughput and overall capability (Hamilton, 2010). In Oman, the restrictions were not as stringent, but a convoy distance of over 60 miles complicated the solution for personnel, staging, and throughput as well (McNabb, 2010).

Capability and accessibility were affected in both Bahrain and Oman, but TRANSCOM's planners and mobility operators were able to overcome obstacles to meet the CENTCOM's requirements. While utilizing the Bahrain and Oman intermodal operations, TRANSCOM was able to identify cost avoidance of $116M per 1,000 M-ATVs shipped each month (McNabb, 2010). Additionally, the deployment timeline was closed faster than transporting solely by airlift, something that may not be inherently obvious based on airlift's supposed advantage in speed.

UAE provided an example of a drawback for military mobility planning for the intermodal sealift-airlift combination. Since the Operations Update slide (Figure 2) was briefed in April 2010, negotiations to utilize UAE for intermodal ops had not been completed and the site could not be utilized. Accessibility, a key service characteristic according to Coyle, was not met. While UAE had a better location with respect to transit time compared to other locations, security and accessibility failed for the TRANSCOM planners (at the time of this writing). Addressing Coyle's concepts of service characteristics of in port selection offers a key insight to the appropriate criteria to examine for best use in intermodal node selection. This is addressed later in this section.

The challenges most apparent to today's military logisticians and policy makers stem from the need for the US military to maximize multiple service characteristics of intermodal transport demand to satisfy combatant commanders' requirements. If there were an unlimited number of strategic and tactical airlifters that could airlift everything, speed and security of transported equipment and personnel wouldn't be an issue. Unfortunately, there are cost and capability gaps that won't allow the US military to operate so recklessly. Cost: Admiral Mike Mullen, Chairman of the Joint Chiefs of Staff, stated that the national debt is "most significant threat to [US] national security" (CNN, 2010). Capability: there will only be approximately 300 strategic airlifters in the Air Force inventory. US forces can't just expect to fly it all and leave it behind when done. Recognizing the relative advantages and disadvantages of recent intermodal operations helps provide context to the AHP TRANSCOM used in port selection and provides a basis for further review of those criteria. Analyzing the specific criteria for selecting intermodal transloading ports is critical to ensuring the success of future intermodal operations. Implications and the use of intermodal operations in the SOUTHCOM AOR are discussed further in Chapter V.

Analytical Hierarchy Process (AHP)

As noted earlier, TRANSCOM developed a model to determine appropriate seaport and airfield pairs for intermodal transloading using an analytical hierarchy program. The actual model used is discussed further in Chapter III of this GRP, but this section covers the basis of AHP and its importance in selection criteria.

AHP offers a means of taking a complex problem with multiple variables and possibly multiple decision makers and offering a means to determine the best decision for their outcome. Dr Thomas Saaty developed AHP to create a hierarchical approach to multi-criteria decision making (Saaty, 1980). Creating a hierarchy of variables, goals, issues, and attributes “provides an overall view of the complex relationships inherent in the situation; and helps the decision maker assess whether the issues in each level are of the same order of magnitude” (Saaty, 1990: 9) to compare accurately. It’s important to note that the hierarchy is not a decision tree, but a means of looking at different sides of the problem. Saaty states that the levels of the hierarchy can be changed, inserted, or eliminated based on the priorities of the decision makers.

AHP takes what could be a nebulous method of decision making and applies considered and factored criteria with their impact on outcome and priority of the decision maker. It is a decision support tool to ensure that there is “uniqueness in the representation of judgments, the scales derived from these judgments, and the scales synthesized from the derived scales” (10). Otherwise the results of arbitrary number assignments to satisfy the participants in the decision making process would result in contradictory and ultimately useless guidance for the decision makers in different situations. The AHP appropriately scales the relative factors, provides effective numbers to use within the problems, and the associated correct priorities that should then result to create a consistent and relevant decision support tool. A key component of this scaling encompasses the two measurements procedures to be used within AHP, and present in the existing TRANSCOM model: absolute and relative.

An absolute measurement applies ranking to alternatives based on ratings (Saaty, 1990). Based on specific criteria, the associated performance can be ranked. The ranking will often be in the form of excellent, good, average, poor (or degrees within) compared to a standard. Then the criterion requirements are applied in ratio to those ranks for a final result. An example in the TRANSCOM model involves the maximum number of aircraft on the ground (MOG) able to be worked (serviced, loaded/unloaded) simultaneously. This can be simply ranked by qualitative numbering, and the airfield in question receives associated percentage (3+: 100%, 2: 80%, 1: 40%, 0: 0%), based on its capability; see further details in Appendix C.

The relative measurement process involves identifying criterion and then determining how they rank to each other in importance. The two steps Saaty discusses are to determine what factors are important in the decision, and then to do a "pairwise comparison of the judgments" (14). When comparing the two criteria they should be compared to importance relative to the overall goal of the decision maker to that problem. In the TRANSCOM model, the rankings of the ten criteria have different ratios of weighting based on their relative importance to the decision maker; i.e. airfield and seaport suitability have the highest ratio, at 15%, compared to the other eight factors.

This means that those two factors have a greater importance when compared pairwise against any other factor in the model.

The great number of variables and decision makers in the logistics supply chain involved with intermodal operations makes AHP valuable for a consistent and effective model to be applied in deliberate and contingency planning situations. AHP offers a means of logically analyzing multiple criteria, determining absolute and relative importance factors, and then making a clear, evidence based decision. Saaty closes his 1990 paper by noting that AHP is a tool to get out of our own “rutted” thinking—getting away from simply following tradition, and “search out better ways that give better answers” (26).

Selection criteria

There are large amounts of literature that are applicable in analyzing selection criteria for node selection in transportation networks (see Macharis and Bontekoning, 2004). This section briefly covers important service components of transportation that give credence to the individual criteria factors that are identified as the most important in selecting transloading port pairs for the military logistician. Following the service demand characteristics, there is a discussion on commercial port selection in academic literature. Finally, assigning appropriate emphasis or weighting to the particular subject criteria is discussed with a special focus on a concept which may negate some of the benefits of the AHP previously discussed.

In his 2011 text on transportation, Coyle emphasizes the service characteristics of freight demand as the primary driver impacting decision makers for shippers. He notes that these characteristics include transit time, reliability, accessibility, capability, and security. As discussed earlier, these characteristics are readily apparent in individual factors at various on-going intermodal transloading hubs in use by TRANSCOM. Providing more weight to any one characteristic impacts port or mode selection, but overall, these characteristics are a consistent theme in the academic literature on effective port selection. Translating the port selection academic theory from solely seaport/rail to truck intermodal, or airfield centric, along with the relations of the five service characteristics that Coyle discusses provides a reasonable basis for effective planning criteria.

In addressing the academic literature on intermodal port pair selection criteria, there is a large amount of data to be analyzed. As discussed earlier, the actual amount of discussion on seaport to airfield transloading is lacking. In this study, the researcher assumes that criteria important in the seaport analysis can be in applied to airfield and airlift criteria for the intermodal transition. The large infrastructure, governmental, and environmental impacts of both seaports and airfields offer parallels in assessing them. To be considered for strategic intermodal operations, seaports and airfields are typically large, slow to be built or changed, inflexible in location, and both be affected by public policy and environmental regulation. The section covers literature discussing network selection and the most important criteria to be incorporated in those decisions.

Caris et al.'s 2008 research provides an overview of planning problems. They cover a large amount of literature in their review on various levels of decision makers (from drayage, terminal, network, and intermodal operators) and effective intermodal planning. They emphasize, again, that the main attention has been applied to intermodal rail transport networks and expect future research to include waterway and barge transport. Interestingly, they neglect the sealift-airlift concept that TRANSCOM has shown to be effective for its use and Raguraman and Chan (1994) identify as being a viable intermodal commercial option. They close with the fact that intermodal planning is complex due to the multiple decision makers and multiple types of shipping units and that the number of research publications regarding planning problems at the operational level remains limited. The planning required in TRANSCOM is operational in nature and the issues associated with strategic intermodal operations can benefit from more of this research.

A number of studies examine port selection criteria and their relative importance to intermodal operations. The results of this area of research are seen in papers from Lirn, Wiegmans, and Murphy with their associated co-writers. Each cover intermodal operations slightly differently, but focus some of their efforts on the right factors to consider in selection criteria. Lirn et al. (2003) identify four "first tier factors" to consider: port physical characteristics, port geographic location, port management, and carriers' cost perspective. Utilizing AHP the writers determine the most important criterion to be the geographic location, and as a second-tier factor, the carriers' loading/discharge cost was the most important in weighting transshipment port selection criteria. Second-tier factors encompassed within the geographic location include "closeness to the import/export consumption areas" and "proximity of the feeder ports" (240). These factors parallel well with factors in the existing TRANSCOM model. The cost consideration does not play as significant a role in the TRANSCOM decision model at this time, but does offer a deep area for further research. With respect to this study, it may be considered that if TRANSCOM needs to move the cargo in support of the mission, the costs will be borne and won't be the primary driver for individual transloading location selection. Overall, Lirn et al.'s research indicate clear parallels with Coyle's concepts in capability (physical characteristics), accessibility (location), and reliability (management).

In a different paper, Wiegmans et al. (2008) discuss port choice criteria from a company perspective on location and facilities. They identify a greater number of criteria that influence the decisions, but there is overlap with the research indicated previously. The criteria Wiegmans et al indicate are listed in Table 1.

Table 1 – Port Choice Criteria

Criteria	*Indicators*
Port physical and technical infrastructure	Accessibility, infrastructure and equipment, intermodal interface
Geographic location	Vis-à-vis immediate and extended hinterland, Vis-à-vis main shipping lanes (diversion distance)
Port efficiency	Port turnaround time, terminal productivity, cost efficiency, operating hours
Interconnectivity of the port	Sailing frequency
Reliability, capacity, frequency and costs of inland transport	
Quality & costs of auxiliary services	
Efficiency and costs of port management and administration	Port dues
Availability, quality and costs of logistic value-added activities	Warehousing
Availability, quality and costs of port community systems	
Port security/safety and environmental profile of the port	
Port reputation	

(Wiegmans et al., 2008: 523)

Their conclusions on port choice strategy indicate that service and cost factors have an equal weight with the strategic considerations for a company. Those strategic implications include fit of the requirements of the alliance structure the companies operate within, existing contracts, market entry and penetration, and arrangements of the lines and terminal operations. While not precisely parallel with operational planning considerations for TRANSCOM, there are theater strategic issues which are important to each combatant commander and can influence where to give the weight of effort to intermodal transloading operations. The factors identified by Weigmanns et al. show clear parallels with each of Coyle's five service characteristics.

Paul Murphy et al. (1988), identify three different primary factors from nine total that influence port evaluations. Their research focuses more on the actual service aspects present at port facilities, as opposed to location concerns which were highlighted in importance in the Lirn and Weigmanns' studies. In the survey conducted by Murphy, the writers note that "equipment availability, low frequency of cargo loss and damage, and convenient pickup and delivery times" (Murphy, et al., 1988: 24) were the three most important factors from the respondents. These three findings correspond to Coyle's characteristics of reliability, security, and accessibility. These received a rating of important or very important by over 80% of the respondents, but over 75% of respondents also rated the ability to allow for large shipments (capability) as important or very important. There are similarities in selection factors from the literature to that from Coyle on what is important related transportation decision making.

Guy and Uli (2006) build on the research in selection factors to assess the impacts of weighting importance on selection behavior. They base their research by accepting quality of infrastructure, cost, service, and geographical location as the accepted best criteria for port selection rationale. They then examined how port preference was affected by changes in criteria weight by using a reverse multicriteria analysis process to understand the conditions that affect changes in port selection. Their premise relies on the fact that they worked from a goal of switching port locations and had a need to understand what weighting scheme for the criteria priorities would have the greatest effect. Their research used multicriteria analysis “as a tool and not the prime object of research” (11) but notes that in manipulating the criteria weightings using the aforementioned accepted criteria they could influence the selection to determine what factor made the greatest impact.

Utilizing this concept, this GRP proposes that the TRANSCOM model (to be discussed in detail in Chapter III) works within the best selection factors already, but may not need the complexities of the AHP weighting priorities that have been generated. The best result may still be determined—saving much effort—without an exhaustive and complex AHP involving every different decision maker. In a content analysis on freight route choice, Cullinane and Toy (2000) state “the inherent difficulty of quantifying abstract influences means they are not easily incorporated into predictive models [for] decision making behavior” (51). By modifying the weighting scheme in use, the same results may be seen as would have occurred in the weighted priority system, but with a faster and easier method of execution for the planners.

The preceding authors discuss the criteria that had importance in port selection. The results illustrate a correlation with Coyle’s concepts of service characteristics of time, reliability, accessibility, capability, and security. To summarize the research’s most important selection criteria identified in various ways: location, capability, security, and reliability. Additionally, by adjusting weighting priorities based on the appropriate selection factors, the use of complex and time consuming AHP may be avoided for future planning operations. Measuring location, capability, and security are easily surmountable tasks. Identifying what to incorporate for reliability generates unique issues related to port abilities as well as being dependent on location specific factors.

This study considers reliability from the perspective of stability. There is a large measure of importance of on-time every-time with respect to reliability for commercial operations. But for the military logistician, reliability may be more represented with respect to macro-level ability for utilization; this parallels somewhat with security, but on a larger-scale, more social and political perspective. One method that can aid in determining reliability analysis is discussed in the following section.

Failed States Index

In evaluating criteria to analyze port selection factors, the literature was abundant and clear on the physical and economic considerations most important to commercial shippers. As TRANSCOM and SOUTHCOM accomplish deliberative and contingency planning, the unique nature of military operations also significantly affects what port pairings should be considered. The existing model in use by TRANSCOM specifically omits “geo-political issues” (Erspamer, 2010). While every individual operational or exercise scenario is the result of its own unique operational environment, considering the current state offers a context for future planning. There are no open source governmental documents that summarize geo-political theater issues that can easily be incorporated in this planning. Additionally, it is assumed that any official governmental sources that spoke to geo-political issues would be considered sensitive and would need to rely on real-time information from the theater to be effective.

In a broader overview for operational planning, commercial products exist that consider a number of geo-political issues. Of special import to consider is the Foreign Policy and Fund for Peace collaborative “Failed States Index.” This listing (see Appendix A), updated annually, considers twelve social, economic, political, and military indicators to generate a relative score within each area and an overall total score that ranks the 177 countries which are evaluated. Utilizing the Conflict Assessment System Tool (CAST) and over 90,000 open-source articles and reports, and then reviewed by subject matter experts (Foreign Policy, 2010), the Failed States Index provides a constant macro-level view of relative geo-political stability for particular regions and countries. The ratings and color schemes seen in the Figure 3 measure countries' relative vulnerability to violence or collapse.

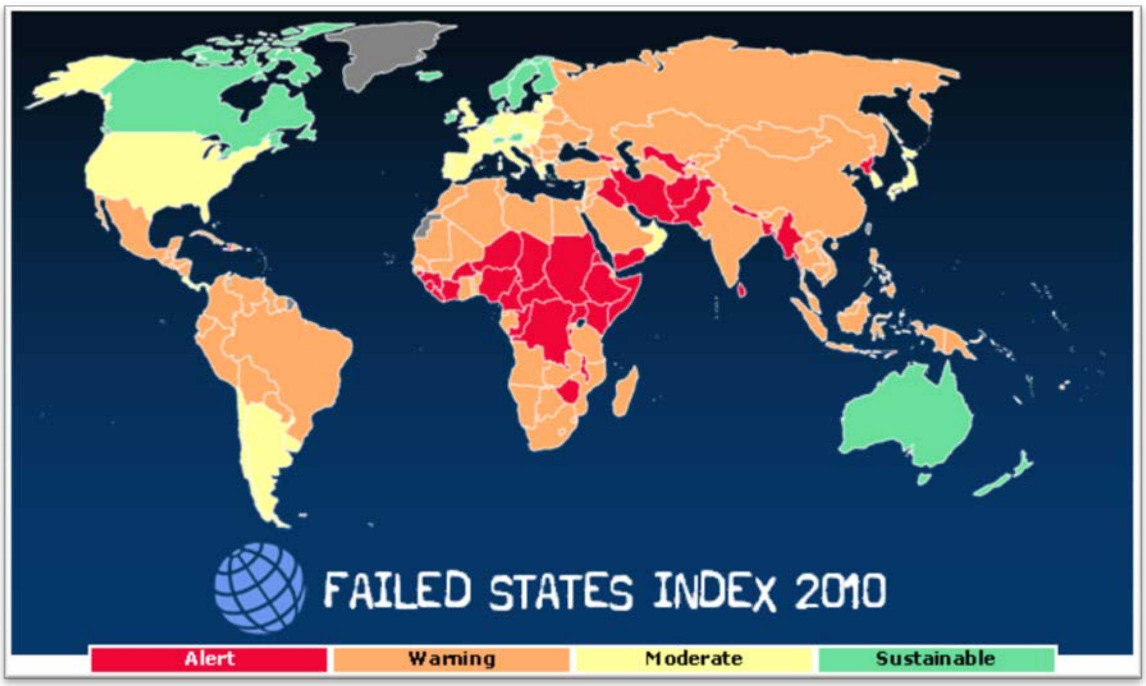

Figure 3 – Failed States Index 2010
(Fund for Peace, 2010)

Foreign Policy states that "[a]ll countries in the red, orange, or yellow categories display features that make significant parts of their societies and institutions vulnerable to failure." It is interesting to note that according to the index, there are relatively few states in the "sustainable" category. Major areas of conflict and concern to the US military exist in the red and orange bands.

The Index offers rigor in its applicability. According to the Fund for Peace, the underlying tool for developing the Index, CAST, has been utilized by the "US State Department, the Government of the Netherlands, the US Army Peacekeeping Institute, the Clingendael Institute, the US Defense Advanced Research Projects Agency (DARPA) and several universities." Additionally, Foreign Policy states that it is in effective use with private sector, governmental, military, and non-governmental agencies. The Index offers a relatively non-biased means of evaluating stability issues for nations. Its categories make analysis for geo-political stability important in the intermodal transloading realm for access and security with respect to seaport and airfield pairings.

With respect to the SOUTHCOM AOR, the Index shows a relatively stable region. This can be correlated with SOUTHCOM's emphasis on Building Partnership Capacity and HADR missions. There is potential for either conflict or lack of access based on the risk of failure or violence as indicated from the Index's data. SOUTHCOM encompasses 31 countries (see Appendix B), who range from ranking at 11th (Haiti) to the 155th ranked (Chile). The average ranking is 102, but with a standard deviation of 36—a relatively large range for the nations. Five countries are not ranked by the Index. The SOUTHCOM countries' Index ranks are listed in Table 2.

Table 2 – Failed States Index Ranking (South America)

Country	***Failed States Index Rank***
Haiti	**11**
Columbia	**46**
Bolivia	**53**
Nicaragua	**66**
Ecuador	**69**
Guatemala	**73**
Honduras	**76**
Venezuela	**83**
El Salvador	**85**
Peru	**92**
Dominican Republic	**93**
Guyana	**102**
Suriname	**105**
Paraguay	**106**
Belize	**112**
Brazil	**119**
Jamaica	**120**
Grenada	**123**
Trinidad and Tobago	**124**
Antigua and Barbuda	**127**
Panama	**130**
Barbados	**135**
Costa Rica	**138**
Argentina	**148**
Uruguay	**154**
Chile	**155**
Cayman Islands	Not Listed
Dominica	Not Listed
St Kitts and Nevis	Not Listed
St Lucia	Not Listed
St Vincent and the Grenadines	Not Listed

The overall ranking of the countries is informative, but the specific twelve criteria that go into the overall score reveal, more closely, geo-political considerations. As stated earlier, the twelve categories are divided in three major areas: social, economic, and political. Using scores from individual areas or overall category scores provide another source of data that may be useful in the model in determining best suited seaport and airfield pairs based on political stability. Table 3 lists each of the indicator categories within the three major areas.

Table 3 – Failed States Index Indicators

Political	***Social***	***Economic***
Criminalization and/or Delegitimization of the State	Mounting Demographic Pressures	Uneven Economic Development along Group Lines
Progressive Deterioration of Public Services	Massive Movement of Refugees or Internally Displaced Persons	Sharp and/or Severe Economic Decline
Suspension or Arbitrary Application of the Rule of Law and Widespread Violation of Human Rights	Legacy of Vengeance-Seeking Group Grievance or Group Paranoia	
Security Apparatus Operates as a "State Within a State"	Chronic and Sustained Human Flight	
Rise of Factionalized Elites		
Intervention of Other States or External Political Actors		

(Fund for Peace, 2010)

Examining the relative scoring in specifically pertinent indicators helps refine the planning solution for intermodal port pair selection. The specific indicators within both the political and economic categories offer a chance to gauge long-term planning stability for the port pairs. States that score low on economic development, rule of law, or deterioration of public services may not be candidates at all, or will score low, in planning for intermodal operations. A robust infrastructure to handle the requirements of large ships and strategic lifting aircraft are prerequisites for large intermodal transfer successes. Incorporating the overall Index score or specific category scores within the context of the existing model can provide a future-view geo-political context for planning.

In actual execution of operational missions, contingency planning will dictate that the most current information and militarily useful intelligence on geo-political issues be utilized. Whereas the Index offers a long view for planning, the idea of utilizing a similarly weighted geo-political score (which would have an AHP absolute score, as discussed earlier), can still be operationally useful for planners to bring as possible courses of action for decision makers. The use of the Failed States Index scores provides a means of bringing context to the service related characteristics in transport criteria analysis and offer value to the TRANSCOM model.

Literature Review Summary

This chapter covered background and literature on intermodal operations, AHP, port selection criteria, and the Failed States Index. By understanding the inherent service related characteristics which are vital in transportation as described by Coyle, time, reliability, accessibility, capability, and security, the results of the academic research are related toward port selection criteria. Utilizing AHP in the existing TRANSCOM model, described in the next chapter, prioritized intermodal transloading seaport and airfield pairs are ranked and decisions on operational planning are made. In assessing the quality of the factors utilized in the current model, some research indicates that priority weightings as a result of AHP may not be valuable, as the most important factors are already incorporated. Finally, by utilizing the Failed States Index, planners have a means of incorporating a theater or country specific factor that relates to reliability (state stability) for long-term planning. Incorporating the details covered in this section, the researcher proposes to identify, in the following chapters, the best criteria for analyzing seaport and airfield pairs for intermodal operations, and highlight those most capable to support military or humanitarian operations in South America.

III. Methodology

This section examines the overall methodology that the researcher engaged to answer the questions posed in Chapter I. By utilizing the TRANSCOM intermodal suitability model and analyzing its output, this research proposes candidates for the best seaport/airfield pair for intermodal transloading in South America to support an operation in a landlocked country. This chapter begins with a detailed description of the TRANSCOM suitability model; explains how data was obtained for South American seaports and airfields, describes the assumptions and limitations; and finally, closes with a description of the experimental process of running the model in four different configurations.

TRANSCOM Intermodal Suitability Model

The model in use by TRANSCOM planners to analyze seaport and airfield pairs for intermodal transloading operations has worked successfully for multiple combatant commanders. As discussed in Chapter II, there are real-world examples of intermodal operations successes that saved money and reduced the deployment timelines as a result of efficient, effective sealift/airlift combinations and well executed transloading between the modes. The model currently in use has been used to analyze ports in the CENTCOM, PACOM, and US European Command AORs. It was developed by the JDPAC in concert with theater joint staff logistics experts and leaders (Erspamer, 2010).

The model is a relatively simple combination of criteria, weighting, and scoring to provide overall suitability ratings to intermodal transloading port pair alternatives. It was developed from an original CENTCOM request to consider over 26 different factors for analysis. The complexity of the dependent variables and data sets required a level of refinement for ease of use and applicability (Alderman, 2011). Interestingly, the initial request included two criteria for political stability: host nation acceptability and support for US policy objectives, weighted at approximately 5% of the total criteria priority. But the final model omitted this subject area.

The resultant model was created with five criteria for each seaport and airfield being evaluated. The criteria, measures, scales, sources, and weights can be seen in Figure 4 with full criteria definitions and value functions available in Appendix C. There are similarities in the criteria between seaports and airfields, each slightly modified to conform to the unique requirements of the mode of transport being received. The criteria align almost precisely with most of the most important factors identified by research and literature previously discussed in Chapter II: location, capability, and security. In the criteria examined at each port, parallels with the service components of transport can be drawn. Reliability is not addressed within the criteria in the model.

	Criteria	Measure	Scale	Source*	Weight
Seaport	Port suitability	LMSR/FSS feasibility	All, most, limited, restricted	TEA assessment	15%
	Port Security	Type/amount of security	Secured, mostly, somewhat, unsecured	TEA assessment	10%
	Port Proximity to airfield	Distance (one way)	Miles (0-200 – continuous)	NGA/TEA	10%
	Port Throughput	TEUs/STPD	High, medium, low	TEA assessment	5%
	Port Cargo Storage Yard	Square footage	Very large, large, medium, small	TEA assessment	10%
Airfield	Airfield suitability	Type of Aircraft	All (C5), limited (C17), restricted (C130)	GIDE TCJ2 smart sheets	15%
	Airfield Working MOG	# of slots	0, 1, 2, 3 +	GIDE TCJ2 smart sheets	10%
	Airfield Staging area	Square footage	Avail, limited, unknown	GIDE	5%
	Airfield Proximity to Afghanistan FOBs	C17 range (round trip)	Maximum, limited, restricted	618/TACC	10%
	Airfield security	Amount/type of security provided	Secured, mostly, somewhat, unsecured	GIDE AFFID	10%

Figure 4 – TRANSCOM Criteria and Weighting

In regard to location, criteria examined for both seaports and airfields are noted in differing ways within the model. The model measures distance between a seaport and airfield when evaluating the seaport, while the airfields are evaluated by distance to FOBs (in Figure 4, it is a CENTCOM-Afghanistan example). The measure for the seaport distance criteria is in continuous miles, while the airfields are measured in comparison to the range of a C-17 roundtrip. This difference in measurement qualities makes sense in the context of how location impacts the next leg in the intermodal transport chain. After cargo arrives at a seaport, it must be transloaded to airlift. The ground leg between the seaport and the airfield impacts the relative strength of the location compared to others. Conversely, when evaluating airfields, the length of the flight from airfield to FOB impacts the relative turn-time on airlift legs that can continue the intermodal movement. The C-17 bridges the gap between strategic and tactical airlift effectively with its combination of range, capacity for outsized or oversize cargo, and austere field capabilities. It is the most likely airlifter to be employed in the second leg of this intermodal transport chain and offers a reasonable measure for the airfield location criteria.

A parallel to the earlier discussed concept of location lies in accessibility. The TRANSCOM model measures accessibility in its highest prioritized category of suitability. Port suitability has the types of vessels that are feasible compared to the largest of the intermodal ships. Airfield suitability is associated with the types of aircraft able to utilize the field.

Capability aligns well with a number of the criteria for both seaports and airfields. The criteria for seaports that fall within the category of capability are listed in the following along with the quantitative measurement for the criteria: throughput measures in twenty-foot equivalent (TEU) or short tons per day (STPD) and cargo storage yard which is determined in square footage. Airfield criteria that align with the capability category are airfield working MOG, measured in numbers of aircraft able to be loaded/unloaded or serviced simultaneously and also airfield staging area measured in square footage.

Security is the final category that encompasses the last criterion in the model. Both seaport and airfields are judged with respect to security. The model lists "amounts/types of security" provided as the quantitative measure, but the scale falls to a relativistic scale of secured, mostly, somewhat, or unsecured. This is a more interpretive analysis and, for the purposes of this research, is assumed equal to avoid operational classification issues.

In looking at the ten criteria incorporated in TRANSCOM's model, there is easy categorization with respect to location, capability, and security. The model specifically omits geo-political issues. Geo-political issues are complex and often very dependent on individual situational contexts. Specific guidance with respect to national strategy, diplomatic strategy, strategic communication, or messaging all have a role in real-time/real-world planning. In a longer term context for planning, these issues can have an effect on reliability and as discussed, reliability is an important factor in port selection. Incorporating a measure for this factor is discussed later in this chapter.

The final piece that is observed in Figure 4 is the last column, weight. This weight is the result of an AHP analysis between JDPAC and the theater joint staff logistics experts and leaders (Alderman, 2011). By going through the iterative process of ranking alternatives and giving quantitative relevance to selection preference between specific categories, the relative weighting factor for the criteria are indicated. These weights do not have to be static, and for different theaters or decision makers, they may change. It is interesting to note that the most important factors indicated for both seaport and airfield is simply suitability (15% weight) while throughput and staging were rated the lowest in importance (5% weight). Six of the ten criteria are weighted equally at 10%. Even with only ten factors, the weighting distribution is approximately normal and the overall average weighting is only 10%. Based on the AHP analysis and weightings that are shown in Figure 4, there is no great preponderance of importance placed on any one factor in evaluating the seaport/airfield pairing. The impacts of the weightings on analysis results are discussed further in Chapter IV.

The actual suitability model takes the criteria previously discussed, applies values to the measures, and then calculates a weighted scoring factor for each criterion. The sum of the criteria for each pair results in an overall "Capability Rating." The output of the model is shown in Figure 5. Figure 5 is an edited version of an actual evaluation run, and shows the scored results of seaport/airfield pairs. The actual seaport and airfield pair names are omitted in the figure.

Seaport Suitability	Seaport Security	Seaport to Airfield Distance	Seaport Throughput	Seaport Cargo Storage	Airfield Suitability	Airfield Working MOG	Airfield Staging Area	Airfield Proximity to AFG FOBs	Airfield Security	Total
15%	10%	10%	5%	10%	15%	10%	5%	10%	10%	100%
All = 100% Most = 75% Limited = 50% Restricted = 0%	Secured = 100% Mostly = 67% Somewhat = 33% Unsecured = 0%	Continuous 0 = 100% 60 = 50% 200 = 0%	High = 100% Medium = 67% Low = 33%	Very large = 100% Large = 75% Medium = 50% Small = 25%	All = 100% Limited = 80% Restricted = 0%	3+ = 100% 2 = 80% 1 = 40% 0 = 0%	Avail = 100% Limited = 50% Unk/none = 0%	Max = 100% Limited = 50% Restricted = 0%	Secured = 100% Mostly = 67% Somewhat = 33% Unsecured = 0%	
Seaport Criteria					**Airfield Criteria**					
Value Wgtd Score	Value Wgtd Score	Value Wgtd Score	Value Wgtd Score	Value Wgtd Score	Value Wgtd Score	Value Wgtd Score	Value Wgtd Score	Value Wgtd Score	Value Wgtd Score	Capability Rating
All 1	Mostly 0.67	5 0.95	High 1	Very Large 1	C-5 1	5 1	Limited 0.5	Maximum 1	Mostly 0.6	0.897
All 1	Secured 1	68 0.45	High 1	Very Large 1	C-5 1	4 1	Limited 0.5	Limited 0.5	Secured 1	0.870
Most 0.75	Secured 1	22 0.78	Medium 0.67	Very Large 1	C-5 1	1 0.4	Limited 0.5	Restricted 0	Secured 1	0.739
All 1	Mostly 0.67	127 0.18	High 1	Very Large 1	C-17 0.8	1 0.4	Limited 0.5	Limited 0.5	Secured 1	0.720
Most 1	Mostly 0.67	260 0	High 1	Very Large 1	C-5 1	1 0.4	None 0	Limited 0.5	Secured 1	0.707
Some 0.5	Somewhat 0.33	5 0.95	Low 0.33	Small 0.25	C-17 0.8	1 0.4	Limited 0.5	Limited 0.5	Mostly 0.6	0.516
Restricted 0	Somewhat 0.33	44 0.61	Low 0.33	Small 0.25	C-17 0.8	1 0.4	Limited 0.5	Limited 0.5	Mostly 0.6	0.430

Figure 5 – TRANSCOM Suitability Model

To employ the model, users identify candidate seaport/airfield transloading pairs and work within Microsoft Excel (or any other suitable tracking means) to evaluate and score the criteria. The color coding scheme helps with visual recognition, but is not critical to the use of the model. The colors are determined via Microsoft Excel conditional formatting as illustrated in Figure 6, below.

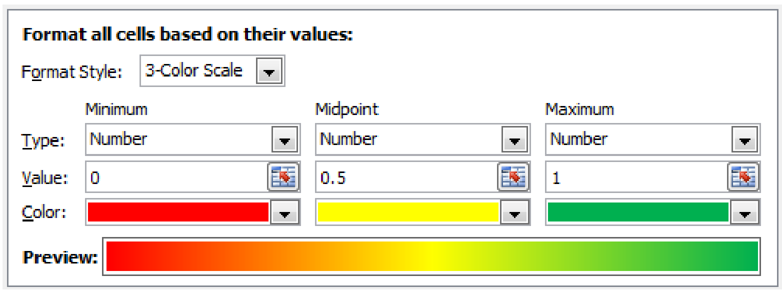

Figure 6 – Suitability Model Conditional Formatting

By evaluating a seaport/airfield pair across the ten criteria previously discussed, the overall capability scores are used to show what port pairs are most suitable for use as intermodal transloading locations.

There are distinct advantages to the model in use by TRANSCOM. As it is based on relatively simple to determine criteria related to the specific seaports and airfields in use, planners can identify candidate locations and focus research efforts on the criteria to put in the model. After evaluating the criteria, the model offers an easy to interpret and actionable results that show the most capable transloading pairs. The model is easily scalable and can be used in specific countries, regions, or theaters depending on infrastructure capabilities and planners' requirements. The color coding and AHP resultant percentage numbers also make senior decision makers' jobs easier by having a well defined and relatable scale that can be applied for analysis—even if that decision maker does not have specific deep expertise in intermodal operations. The decision maker would be assumed to have broader operational knowledge of mission requirements, as well as political or theater objectives that would be incorporated in the final decision. This does reveal a weakness of the model.

It has been mentioned that the model does not incorporate geo-political issues. That would indicate that the final decisions on capability would then rest with leaders or decision makers who should have that background. That may or may not always be the case. The geo-political aspects are one component of reliability of a location, but as very recent incidence have shown in Tunisia, Egypt, Bahrain, and Libya, instability can arise from more than political activities. Upheaval in national or regional stability can have a significant impact on reliability of a seaport/airfield pairing to be an effective location to base planning.

Another unique weakness that can exist in the model is, ironically, the easy to interpret color and scoring scheme. From a usability standpoint, firm quantitative numbers and evaluation criteria (red, yellow, green) can offer a false sense of expert knowledge and confidence that the solution provided via the model is both effective and correct. Underlying errors in data sources, acquisition, or analysis may hide significant issues that adversely affect the quality of the results provided from the model.

In this project, the researcher accepts the existing model as effective and correct for the situation to be presented. While not changing the overall nature or structure of the model, both criteria and weightings are modified to assess the impacts of changes and help answer the research questions posed in Chapter I.

Data Set

Determining the best suited seaport and airfield pairing for intermodal transloading operations in South America requires data on both seaports and airfields in the SOUTHCOM AOR. Data regarding seaports and airfields in SOUTHCOM came from a variety of sources. The researcher did encounter some difficulties in acquiring specific types of data due to information classification, incomplete data systems, and a lack of an integrated information technology system across the entire distribution process. Primary sources for seaport data came through internet data mining, analysis of the IRRIS databases for SOUTHCOM seaports, evaluation of TEA seaport reports, and a port evaluations conducted by the 832d Transportation Battalion operations division (S3), which is the single point of contact for the Army component of TRANSCOM, the Surface Deployment and Distribution Command (SDDC), to SOUTHCOM. Airfield data came primarily from the ASRR as well as JDPAC analysis of Tanker Airlift Control Center (TACC) Planners Reports on airfields. Fields without specific planners' data were analyzed by overhead imagery (typically Google Earth) and use of the World Aeronautical Database. There were a number of steps that were required to take the raw data and get usable information for use in the suitability model.

The seaport data was the primary driver in determining what airfields were required to be analyzed. Seaports, by the nature of their locations, drove the requirement in identifying appropriate airfields. Another factor affecting seaport evaluation was the ports' ability to handle large cargo ships such as the Large, Medium Speed Roll-On/Roll-Off (LMSR), the Fast Sealift Ship (FSS), or their commercially contracted equivalents. To reiterate one of this research's basic assumptions, this analysis is based around large scale strategic lift, and that basis eliminates a number of non-open water accessible or shallow draft ports. After identifying the port locations that had reasonable data and evaluations, the researcher extracted the relevant details from port reports to obtain measures that correlated with the criteria in the TRANSCOM suitability model. The measures were evaluated with respect to the scales previously discussed in the model.

Certain assumptions are required with seaport analysis measures based on the availability, currency, and quality of data from seaport surveys. Where no specific information was available, reasonable judgment based on overhead imagery analysis (typically Google Earth), for storage and staging area size, and port berthing arrangements as well as public sources for port capabilities was used by the researcher. Additionally, throughput analysis, when available via surveys was utilized, but if not associated with the individual ports, was assumed to be “high” for well developed port facilities in accordance with similar assumptions made by TRANSCOM planners.

After identifying the candidate seaports, determining their airfield pair was a relatively easy task. Many of the seaport evaluation reports listed the closest airfield(s) for reference; this became the seaport/airfield transloading pair to be evaluated. As part of the verification of data integrity, the researcher ensured that the airfields selected were suitable for strategic airlift aircraft (C-5 or C-17) and were found in AMC’s ASRR. The ASRR provides current, detailed and expanded suitability policy guidance derived from AMC instructions and dictates that AMC missions may only operate from fields which are listed in the ASRR. After verifying the airfields’ applicability, the measures for each field were evaluated with respect to the scale previously discussed.

Determining distances between seaports and airfields was accomplished by one of three methods. If there was distance to airfield described in the port survey, that distance was utilized. If there was no distance in the port survey, the researcher utilized Google Earth imagery and mapping tools to determine the road distance from port facility to airfield entrance. When available within Google Earth, actual road directions and distances were automatically calculated via the "Get Directions" tool within the program. If the system was unable to generate map directions, the researcher resorted to approximation of distances using visible major roads between the port facility and the airfields with the measurement path tool. This allowed a reasonable estimation of the distances without further extensive site surveys or simply using straight-line radius measurements. When the measuring approximation was utilized, the distance criteria are italicized.

There were also assumptions made in the airfield analysis. As some fields did not have full data, based on the currency or completeness of information in Airfield Planners Reports from AMC's TACC, some airfields were assessed outside the planners reports' data. The researcher applied reasonable judgment in assessing these fields for analysis. Limitations of the model's applicability exist as a result of these assumptions and are further discussed in Chapter V. Airfields lacking TACC Planners Reports are indicated with an asterisk in the model seen in Appendix E. To be truly usable, the fields without planners reports require an airfield survey by TACC prior to use as an operational airfield for AMC aircraft.

Additionally, MOG assumptions were required on some of the fields. The planners reports indicated parking MOG, contingency MOG, working MOG, or no available data for some or all aircraft. With incomplete data, the researcher assumed that if a field was suitable, and ramp space for aircraft existed, a working MOG of two was feasible. This assumption is based on the capabilities of a basic Contingency Response Element (CRE) offering a working MOG of two in 24-hour period (Carrabba, 2011). The CRE is the airfield opening component of the JTF-PO and is an appropriate means for executing the intermodal transloading operations, and has been proven (USTC, 2009). Finally, if no MOG was indicated, ramp space limitations were assessed and a MOG of one was indicated if applicable. These assumptions are indicated with italicized working MOG values in Appendix E.

A change in the criteria evaluated for airfields within the model is required to make the scenarios examined applicable to the SOUTHCOM AOR. In the example illustrated in Figure 4, the proximity to Afghanistan FOBs is listed. In the context of this research, the aircraft range determination is with respect to locations in South America, rather than Afghanistan. The C-17 has a range of approximately 2,400 nautical miles without refueling (Air Force, 2011). For an unrefueled round trip mission, which is the criteria measure for airfield location, the researcher determined scale as noted in Table 4:

Table 4 – Value Function for Distance to FOB

Distance in Nautical Miles	Scale Rating
0 – 1,199	Maximum
1,200 – 2,200	Limited
>2,200	Restricted

The ratings are determined based on operational assumptions for C-17 utilization. The range associated with the maximum rating allows two round trips between an intermodal transloading hub and the subject airfield in SOUTHCOM. The limited rating allows only a single round trip, but still offers some additional range and capability for flexibility in operations. The restricted rating may not allow for a single sortie to depart and return without another refueling stop based on the distances involved. Aircraft operating missions to that range may lose flexibility due to the non-refueling planning nature of the evaluation.

For distance calculation, the researcher assumed an event requiring intermodal operations to a landlocked country, in this case Bolivia. In examining population density and propensity for HADR or other major operations, the majority of population in South America clusters near the coastal regions or near the mountain ranges cutting through Chile and Bolivia, as illustrated in Figure 7.

Figure 7 – South America Population Density
(Columbia University, 2005)

Much of the terrain and infrastructure of South America makes overland transport difficult. The benefits of intermodal operations can be utilized for direct delivery from the seaports, or even aerial delivery if required to any location on the continent. For the purposes of range measurements in this analysis, the FOB was considered to be Bolivia's primary airfield, Viru Viru International Airport. It is centrally located on the continent, suitable for all AMC aircraft, and provides a logistical challenge that intermodal operations of the type described can help overcome. Viru Viru's location relative to the proposed intermodal port locations can be seen in Figure 8.

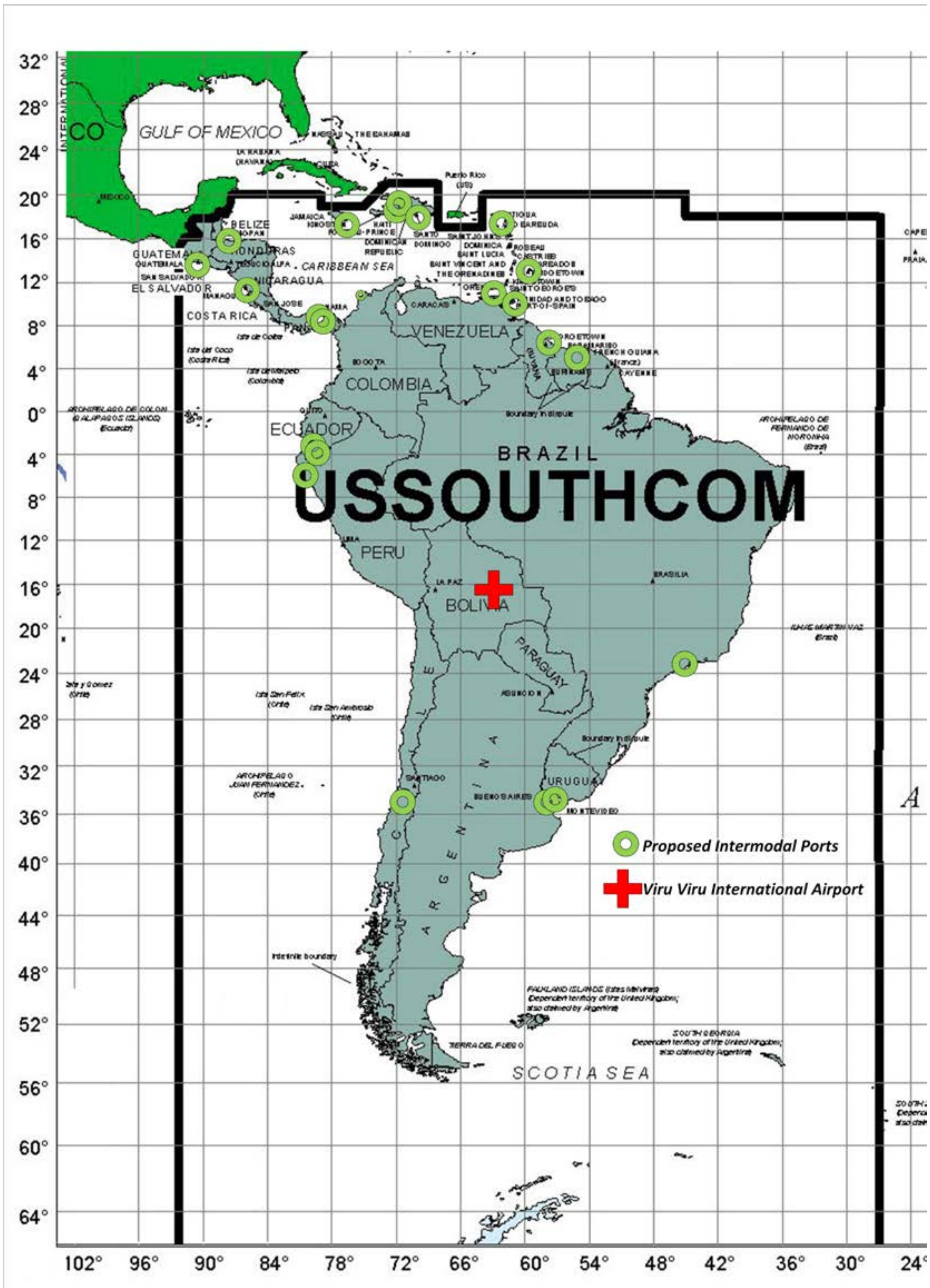

Figure 8 – SOUTHCOM AOR and Proposed Intermodal Locations

Additionally, it was noted that security is one of the four most important factors to be considered in port pair selection. In order to allow for public release in this research, the security measure and scale is normalized for all locations. No specific notations of types, amounts, or relative differences between different candidate port pairs' security ratings are associated within the model. With equal weight and equal scores, security does not affect the results of the different modes of running the model.

As mentioned in the relative strengths of the TRANSCOM model, the researcher used MS Excel as the tool for collating and analyzing the measures, ratings, and overall capability ratings for the seaport/airfield transloading pairs. The TRANSCOM model is unclassified but resides on classified information technology systems (Erspamer, 2010 and Alderman, 2011). Recreating the model in Microsoft Excel provided the opportunity for the researcher to make changes to criteria, weighting priority, and rapidly execute different trials of the model to answer the research questions posed in Chapter I.

Acquiring, collating, and analyzing the raw data associated with seaports and airfields in the SOUTHCOM AOR presented unique challenges. Mountains of data exist, but bringing the correct pieces together in an efficient and effective manner is possible through the combined use of expert organizations such as JDPAC and the 832nd Transportation Battalion. How that data is utilized in the context of the TRANSCOM model, along with different modes of analysis, is explained in the following section.

Executing the Model

By running the TRANSCOM model in four different variations, the researcher provides answers to the questions posed in Chapter I. The preponderance of evidence from academic research and literature noted in Chapter II reveal the most important factors for analysis are location, capability, security, and reliability. Without changes, the model identifies the best seaport and airfield pairs for intermodal transloading in SOUTHCOM with respect to location, capability, and security while not addressing geo-political issues. By noting that the best factors have likely already been incorporated in the model, analyzing the differences in results after equalizing each criteria weighting priority, the researcher can determine if there is utility in going through an AHP for different theaters or regions in utilizing the TRANSCOM model. Finally, incorporating the Failed States Index scores associated with the port pair locations provides results that offer context to the reliability characteristic as a result of national stability which can be associated with the port pairs.

Therefore, the researcher chose to utilize the TRANSCOM suitability model in the following four methods (incorporating the previously noted assumptions regarding field proximity and security):

1. Existing TRANSCOM model with no changes
2. Trial 1 – Equal weighting priority for all criteria
3. Trial 2 – Incorporate a "Stability" criterion based on the Failed States Index and the country; with weighting on all criteria remaining equal
4. Trial 3 – Incorporate "Stability" criterion and utilize weighting priority; stability being weighted at 5% and all others reduced by 0.5% (based on earlier discussed concepts from original requestors)

To evaluate an appropriate scale for the third iteration of the model incorporating the Failed States Index measure, the researcher used value function described in Table 5.

Table 5 – Failed States Index "Stability" Criteria Definition and Value Function

Index Total Points	Color Code	Category	Scale Rating
< 30	Green	Stable	100%
30 – 59	Yellow	Moderate	67%
60 – 89	Orange	Warning	33%
≥ 90	Red	Alert	0%

Two examples of the model, containing notional port locations and data are seen in the following figure. Figure 9 illustrates the existing TRANSCOM model with no changes as well as Trial 2 with a stability criterion, but equal weightings. Depictions of the model with actual locations and data are in Appendix E. As parts of the specific data incorporated in the models are controlled unclassified information for operational use, Appendix E is available under separate cover. These notional examples are presented in this chapter so the reader may see an example of the model output in full form.

Utilizing the data and the model as discussed in this chapter provided means of assessing the best seaport and airfield intermodal transloading pairs for SOUTHCOM with respect to a subject field in Bolivia. It also allowed analysis of the impact of changes to the weighting priority and the addition of a measure for reliability. The results of the model trials and their implications are discussed in the following chapters.

Original TRANSCOM Model

Notional Seaports and Airfields

Notes:
* indicates airfield was not listed in TACC Planners Reports
† indicates no port survey materials available through TRAN
Italicized values are assumptions based on best analysis of

Seaport / Airfield	Country	Seaport Suitability	Seaport Security	Seaport to Airport Distance	Seaport Throughput	Seaport Cargo Storage	Airfield Suitability	Airfield Working MOG	Airfield Staging Area	Airfield Proximity to FOB	Airfield Security	Total
Weight		15%	10%	10%	5%	10%	15%	10%	5%	10%	10%	100%
		All = 100% Most = 75% Limited = 50% Restricted = 0%	Secured = 100% Mostly = 67% Somewhat = 33% Unsecured = 0%	Continuous 0 = 100% 60 = 50% 200 = 0%	High = 100% Medium = 67% Low = 33%	Very large = 100% Large = 75% Medium = 50% Small = 25%	All = 100% Limited = 80% Restricted = 0%	3+ = 100% 2 = 80% 1 = 40% 0 = 0%	Avail = 100% Limited = 50% Unk/none = 0%	Max = 100% Limited = 50% Restricted = 0%	Secured = 100% Mostly = 67% Somewhat = 33% Unsecured = 0%	
		Seaport Criteria					**Airfield Criteria**					
Seaport / Airfield	Country	Value / Weighted Score	Value / Weighted Score	Value / Weighted Score	Value / Weighted Score	Value / Weighted Score	Value / Weighted Score	Value / Weighted Score	Value / Weighted Score	Value / Weighted Score	Value / Weighted Score	Capability Rating
Seaport A	A	Most	Mostly	11	*Medium*	Medium	All	2	Limited	Restricted	Mostly	0.587
Airfield A		0.75	0.67	0.89	0.67	0.5	1	0.8	0.5	0	0.67	
Seaport B	B	Most	Mostly	2	*Medium*	*Large*	Restricted	*1*	None	Limited	Mostly	0.490
Airfield B		0.75	0.67	0.98	0.67	0.75	0	0.4	0	0.5	0.67	
Seaport C	C	Most	Mostly	33	*Medium*	*Medium*	Limited	1	None	Limited	Mostly	0.514
Airfield C		0.75	0.67	0.70	0.67	0.5	0.8	0.4	0	0.5	0.67	
Seaport D	D	All	Mostly	*5*	*Medium*	Small	All	*2*	Limited	Max	Mostly	0.683
Airfield D		1	0.67	0.95	0.67	0.25	1	0.8	0.5	1	0.67	
Seaport E	E	Limited	Mostly	*8*	*Medium*	*Small*	All	*2*	Limited	Limited	Mostly	0.589
Airfield E		0.5	0.67	0.92	0.67	0.25	1	0.8	0.5	0.5	0.67	
Seaport F	F	Limited	Mostly	*110*	*Medium*	*Small*	All	*2*	Limited	Limited	Mostly	0.520
Airfield F		0.5	0.67	0.16	0.67	0.25	1	0.8	0.5	0.5	0.67	

Trial 2 - Incorporate a "Stability" criterion based on the Failed States Index and the country

Notional Seaports and Airfields

Seaport / Airfield	Country	Seaport Suitability	Seaport Security	Seaport to Airport Distance	Seaport Throughput	Seaport Cargo Storage	Airfield Suitability	Airfield Working MOG	Airfield Staging Area	Airfield Proximity to FOB	Airfield Security	Failed States Index Score	Total
Weight		9%	9%	9%	9%	9%	9%	9%	9%	9%	9%	9%	100%
		All = 100% Most = 75% Limited = 50% Restricted = 0%	Secured = 100% Mostly = 67% Somewhat = 33% Unsecured = 0%	Continuous 0 = 100% 60 = 50% 200 = 0%	High = 100% Medium = 67% Low = 33%	Very large = 100% Large = 75% Medium = 50% Small = 25%	All = 100% Limited = 80% Restricted = 0%	3+ = 100% 2 = 80% 1 = 40% 0 = 0%	Avail = 100% Limited = 50% Unk/none = 0%	Max = 100% Limited = 50% Restricted = 0%	Secured = 100% Mostly = 67% Somewhat = 33% Unsecured = 0%	Stable = 100% Moderate = 67% Warning = 33% Alert = 0%	
		Seaport Criteria					**Airfield Criteria**					**Stability**	
Seaport / Airfield	Country	Value / Weighted Score	Value / Weighted Score	Value / Weighted Score	Value / Weighted Score	Value / Weighted Score	Value / Weighted Score	Value / Weighted Score	Value / Weighted Score	Value / Weighted Score	Value / Weighted Score	Value / Weighted Score	Capability Rating
Seaport A	A	Limited	Mostly	4	*Low*	Small	All	*1*	Avail	Limited	Mostly	Warning	0.601
Airfield A		0.5	0.67	0.96	0.33	0.25	1	0.4	1	0.5	0.67	0.33	
Seaport B	B	Most	Mostly	11	*Medium*	Medium	All	2	Limited	Limited	Mostly	Moderate	0.693
Airfield B		0.75	0.67	0.89	0.67	0.5	1	0.8	0.5	0.5	0.67	0.67	
Seaport C	C	Limited	Mostly	11	Low	Small	Limited	3	Limited	Restricted	Mostly	Warning	0.540
Airfield C		0.5	0.67	0.89	0.33	0.25	0.8	1	0.5	0	0.67	0.33	
Seaport D	D	All	Mostly	66	High	Medium	Limited	*1*	Limited	Max	Mostly	Moderate	0.714
Airfield D		1	0.67	0.44	1	0.5	1	0.4	0.5	1	0.67	0.67	
Seaport E	E	All	Mostly	*5*	High	Large	All	1	None	Limited	Mostly	Warning	0.661
Airfield E		1	0.67	0.95	1	0.75	1	0.4	0	0.5	0.67	0.33	
Seaport F	F	Most	Mostly	2	*Medium*	*Medium*	Restricted	*1*	None	Limited	Mostly	Stable	0.558
Airfield F		0.75	0.67	0.98	0.67	0.5	0	0.4	0	0.5	0.67	1	

Figure 9 – Model Examples (Notional Data)

IV. Results

This section discusses the results of the data analysis and model execution as described in Chapter III. After interpreting original data sources and consolidating pertinent values into the specific models, simple spreadsheet analysis of the data was accomplished with the complete results detailed in Appendix D and Appendix E. In reference to the research questions posed in Chapter I, specific results are described.

Model Results

A simplified summary of the top intermodal transloading port pairs for each trial of the model follows. The capability ratings in each trial cannot be compared directly to other trials due to modifications of the weighting and criteria, but offer a chance to perform sensitivity analysis as a result of the differences between trials.

The first results illustrate what seaport and airfield port pairs are best suited to support intermodal transloading operations in support of an event at an airfield in central Bolivia. Table 6 has the top port pairs as determined by the existing, original TRANSCOM suitability model. The Port of Montevideo, Uruguay, receives the highest capability rating based on a number of factors: accessibility, capability, and transit time (location).

Table 6 – Original TRANSCOM Model Results

Rank	*Seaport*	*Airfield*	*Country*	*Capability Rating*
1	Port of Montevideo	Carrasco International	Uruguay	.802
2	Santos (Sau Paulo)	Congonhas	Brazil	.796
3	Port of Buenos Aires	Ezeiza Ministro Pistarini	Argentina	.758
4	Corinto	Managua International	Nicaragua	.753

Table 7 illustrates the top port pairs to select if the priority weighting of criteria are removed from the TRANSCOM model and all have equal weights.

Table 7 – Trial 1 Equal weight priority for all criteria

Rank	*Seaport*	*Airfield*	*Country*	*Capability Rating*
1	Santos (Sau Paulo)	Congonhas	Brazil	.781
2	Port of Montevideo	Carrasco International	Uruguay	.777
3	Port of Balboa	Howard	Panama	.761
4	Port of Buenos Aires	Ezeiza Ministro Pistarini	Argentina	.745

The top port pair preference saw a switch between Santo, Brazil, and Port Montevideo. The Port of Balboa, Panama, now appears as the number three choice when criteria weightings are removed (it rose five positions in preference from the original results). This is interesting as a Panamanian seaport offers a significantly shorter sea-steaming time compared to Brazil or Uruguay. But Balboa's accessibility to all LMSR or FSS ships is limited compared to the other seaport choices in the top four results.

The results shown in Table 8 incorporate the Failed States Index score as a measure of stability, with respect to the service characteristic of reliability for port selection as noted in Chapter II.

Table 8 – Trial 2 Incorporated "Stability" criterion; all criteria remaining equal

Rank	*Seaport*	*Airfield*	*Country*	*Capability Rating*
1	Port of Montevideo	Carrasco International	Uruguay	.767
2	Port of Balboa	Howard	Panama	.753
3	Santos (Sau Paulo)	Congonhas	Brazil	.740
4	Port of Buenos Aires	Ezeiza Ministro Pistarini	Argentina	.738

In this case, the Port of Montevideo in Uruguay is the preferred choice as its stability rating was better at "Moderate" compared to "Alert" for Brazil according to the Failed States Index score. The top port pairs identified in this trial remain the same, but their preference order is affected by stability—which is considered a reasonable measure for reliability in this research.

Finally, Table 9 incorporates both the stability criteria and reintroduces the criteria weighting priorities from the original TRANSCOM model. Adjustments in the original weighting scale were required to give 5% weight to the stability score, and was accomplished by subjecting 0.5% from each of the original criterion weightings equally.

Table 9 – Trial 3 Incorporated "Stability" criterion and utilize weighting priority

Rank	*Seaport*	*Airfield*	*Country*	*Capability Rating*
1	Port of Montevideo	Carrasco International	Uruguay	.796
2	Santos (Sau Paulo)	Congonhas	Brazil	.773
3	Port of Buenos Aires	Ezeiza Ministro Pistarini	Argentina	.754
4	San Antonio Port	Comodoro Benitez Int'l	Chile	.741

Again, Port of Montevideo is the preferred choice based on accessibility, capability, transit time, and reliability. Use of the criteria weighting schemes affects these results in giving greater preference for more accessible (suitability) and reliable (stable) port pairs. Port of Balboa fell in preference compared to the results in Table 8 due to its lesser accessibility and capability (which were weighted the highest) while San Antonio Port's accessibility, capability, and reliability pushed it into the top four results compared to the previous trials where it was not in the top choices.

Overall, the Port of Montevideo in the capital city of Uruguay is identified as the best seaport and airfield pair for intermodal transloading operations in South America, in supporting an operation in central Bolivia. By the original TRANSCOM suitability model and each of the variations attempted in this research the results are consistent. The port has good deep-water ship suitability, close airfield access, and high throughput

(Uruguay, 2011) as well as a very low ranking (#154) in the Failed States Index revealing a stable and reliable nation. In the context of this analysis, its relative close proximity to airfields in Bolivia also play a strong part in its preferred selection status. What the results of this model do not associate, though, are the impacts of location of the Port of Montevideo compared to the other proposed locations. It is nearly twice the sea-steaming distance further south than the majority of the other port pairs considered. There is further discussion on the impacts of sea-steaming distance in Chapter V.

In analyzing the results of the suitability model and various experimental trials, the best seaport/airfield pair for intermodal transloading in support of an operation in central Bolivia, South America is determined. How the overall research in this GRP answers the questions posed in Chapter I follows.

Research Question Results

Through the literature review and use of the TRANSCOM suitability model in various trials, the researcher believes that the questions proposed in Chapter I have yielded reasonable results to confirm the quality and effectiveness of the TRANSCOM suitability model. This section briefly restates those questions and provides answers as a result of the overall research.

Question 1 – What are the most appropriate factors to consider for selection preference of operationally effective port pairs? A thorough review of the academic literature affirms the importance of five factors in determining port locations in logistical and intermodal networks: accessibility, capability, security, transit time, and reliability. The five criteria that are assessed in the TRANSCOM model for seaport and airfields adequately cover four of the five characteristics for assessing selection preference in port locations; the reliability characteristic is omitted. The original planners at TRANSCOM took the operationally complex requirements of combatant commander logisticians and effectively distilled the essential aspects to consider for port pair selection when they originally developed the model. They specifically chose not to consider geo-political aspects, which this researcher believes can speak to the reliability of the port pair selection. In summary, the existing factors considered in the TRANSCOM model are operationally effective for determining selection preference. To align the factors of the model with the characteristics described above, see Table 10.

Table 10 – Selection Factor Correlations

	Service Characteristic	*TRANSCOM Seaport Equivalent*	*TRANSCOM Airfield Equivalent*
1	Accessibility	Suitability	Suitability
2	Capability	Throughput, Cargo Storage	Working MOG, Staging Area
3	Transit Time	Distance to Airfield	Proximity to FOB
4	Security	Security	Security
5	Reliability	*Not considered*	*Not considered*

Question 2 – Are the weighting factors utilized by TRANSCOM effective in determining best seaport and airfield pairs? The researcher proposed that since the TRANSCOM planners had made effective choices in determining the best factors to consider in port pair preference, that the AHP and criteria weightings are not as important as using the best factors. This may result in time and effort savings by eliminating any requirement to conduct AHP in different theaters or with different sets of logistical planners or combatant commander customers.

The results in this situation as a result of the model trials are more complex. In analyzing the model variations in Appendix E, seaport suitability has one of the greatest impacts in the weighted model compared to the non-weighted. Airfield suitability has the same weighting priority, but there were twice as many airfields that were suitable for all aircraft compared to seaports suitable for the largest intermodal ships in the planning. This resulted in an accessibility limited seaport (Balboa, Panama) moving far higher in preference than in the weighted model. As discussed earlier in this chapter, there may be advantages to a closer steaming location (Panama compared to further south in SOUTHCOM) that outweigh limitations in seaport accessibility. But overall, maintaining greater accessibility was shown to be important to the combatant commander planners and makes sense with respect to operational flexibility. The results provided by the equal weighting trial raise questions to their operational effectiveness and may not be the best means of selection preference.

Question 3 – What factors, different from those already in use by TRANSCOM, can be identified to evaluate seaport and airfield pairs for intermodal transloading? Again, by way of the literature review, the introduction of a factor to account for reliability may benefit the TRANSCOM model in longer-term planning considerations. The researcher proposes that the Failed States Index score offered a means of associating a broad range of open-source information to provide guidance on stability in nations and reliability with respect to logistical planning. As a result of the trials of the TRANSCOM model using a stability factor, the preferred port pairs did change, boosting those in more stable countries and providing an insight on what locations may have the greatest potential for long-term planning or use. By helping to identify which countries' locations may not be suitable, for stability or reliability issues, planners can effectively plan, modify existing plans, or champion opportunities at the most capable locations as identified by the model.

Question 4 – By using newly selected criteria to modify the TRANSCOM model, how does the best seaport and airfield pair selection differ? This question is covered in the actual model results previously discussed comparing Table 6 and Table 9 results. The overall scores and results of this experiment can be seen in detail in Appendix D. Due to the effectiveness of the original planners' model development and criteria choice, the top three seaport and airfield pairs are the same when incorporating new factors. Port Montevideo, Uruguay, and Santos, Brazil, remain as the best choices to support intermodal transloading operations in support of an event in central Bolivia, South America.

V. Conclusions and Recommendations

Conclusions

The results discussed in Chapter IV offer evidence to support the concepts researched through this process. The criteria considered by TRANSCOM planners when developing the intermodal suitability model cover the most important factors in port pair selection criteria. The addition of another factor, in the form of the Failed States Index, to consider nation-state stability as a measure of long-term reliability, offers further clarity for intermodal operations planning. The AHP developed weighting system for rank ordering the criteria priorities also presents more realistic and operationally effective analysis for seaport and airfield pairing rather than having all criteria equalized in priority.

When considering a notional operation to support military operations or HADR in a land-locked country in South America, the ports in Uruguay, Brazil, and Argentina offer the highest capability ratings with respect to the factors considered by TRANSCOM planners. The results remain the same when including considerations for geo-political stability as a measure for reliability. Acknowledging that each particular operational scenario has its own unique political or national contexts, using the stability measurement to focus efforts for Building Partnership Capacity or infrastructure planning can be informative for military planners.

Limitations

In the context of broader applicability, the research is limited by the study of the existing TRANSCOM model. The model was created in response to a combatant commander tasking, was found to be effective and utilized in a number of real-world situations. TRANSCOM has made no modifications to the model in its use for forward moving intermodal operations in CENTCOM, PACOM, and US European Command. The model was adjusted to include a factor for equipment cleaning on retrograde operations, but otherwise has been operationally effective in three major geographic commands. SOUTHCOM and US African Command (AFRICOM) are the two major geographic combatant commands outside the continental US not currently performing operations with this model. They may benefit from the new analysis this GRP offers. For the rest of the world, the only changing factors may be related to FOB locations depending on changing contingency locations.

Additionally, the research on this model may be limited in applicability supply chain studies outside military logistics. As noted, there are only limited situations in which the commercial world utilizes the sea-air intermodal option. It is a mode which is valuable to military planners due to the breadth of locations and speed with which the US military may have to conduct operations. Disaster relief agencies or firms, and non-profits or non-governmental agencies may see benefits in the concepts presented.

There are limitations to the fidelity of the analysis based on the quality of data available to be input in the model. The vast majority of SOUTHCOM seaport survey reports were in excess of five years old, some were over a decade since their last update. The same held true for a large percentage of the reports on airfields. This is understandable as the focus of operations in the last ten years has been in CENTCOM. Also, the bulk of ports with adequate surveys are in the northern tier of SOUTHCOM. It is worth noting that the data for the best port pairs identified in Chapter IV came from open-source research, as there were no surveys available to the researcher from

TRANSCOM or SDDC sources for almost 20% of the countries in the SOUTHCOM AOR. To remain clear of classification issues, as previous noted, security considerations are equalized across all facilities examined. As one of the major characteristics for selection preference, the results could be greatly modified based on real-world security considerations. Finally, the selection of a single FOB in a landlocked country in South America limits overall applicability of the specific results to that example. As mentioned earlier, the timeliness criteria has an effect on overall capability rating and a differently located subject FOB could easily result in significantly different top transloading pairs for South America.

While there are some applicability and fidelity limitations associated with the results of the model execution, the impact of verification of the model's effectiveness and veracity remain of value. Providing academic basis and confirmation that the factors considered by TRANSCOM planners are the best for seaport and airfield pair selection revealed that process and operations previously conducted were effective uses of limited logistical resources in support of global combatant commanders' requirements. The limitations noted above offer areas for further study or planning for military logisticians; this project also generated other concepts that would benefit from further research. Those areas are discussed after a brief discussion of recommendations based on the conclusions and limitations of this study.

Recommendations

TRANSCOM and theater planners should continue to use the intermodal suitability model with confidence that the factors considered and the weightings associated with the criteria are appropriate for effective and best selection preference in those port pairs. Ultimately, TRANSCOM has already chosen to utilize the model for intermodal transloading capability analysis (Alderman, 2011). The addition of reliability criteria, this research proposes use of the Failed States Index or one of its sub-criteria related to reliability, can provide further insight with respect to deliberative long-term planning. It is limited in contingency planning based on the exigencies of the individual operation and the associated political, operational, and geographic constraints involved in each unique event. The operational benefits of the weighting scheme, which may require AHP updates based on user preferences does offer a more effective proposal of best alternatives and should remain a part of the model.

The benefits of intermodal operations are best seen when large quantities of relatively low-value or bulky items must be moved a long distance. Utilizing the airlift segment in the shortest leg, to increase utilization, increases velocity and ultimately can result in closing deployment timeliness faster and at less cost than by relying solely on strategic airlift from the continental US. The intermodal option may be utilized in SOUTHCOM for kinetic combat operations as seen in the CENTCOM theater, exercise and training events as seen in PACOM, and in Building Partnership Capacity as is one of the focuses of SOUTHCOM. Additionally, as seen after the recent earthquake in Haiti, HADR operations can benefit from both strategic sealift and airlift – perfect for utilizing the intermodal option for direct delivery or aerial delivery.

The use of the capability ratings from the intermodal suitability model is effective in garnering the most capable seaport and airfield pairs to analyze in a continent or theater context. Utilizing a finer grained analysis to compare the identified best choices is a prudent recommendation as well. Understanding limitations in the data sources and analysis from the model allows planning and operational efforts to focus on those best choices for an ultimate optimal choice for intermodal transloading. Additionally, selecting multiple sea-air intermodal transloading locations presents a unique challenge that isn't adequately addressed within the existing model or criteria. In that case, individual circumstances of the event at hand require the synchronized efforts of theater experts, inter-agency collaboration, and distribution process components to pick that optimal seaport and airfield pair(s). Areas for further study encompass some of these concepts.

Areas for Further Study

While offering proposals to support operations in central South America, there are other related topics which have potential for further investigation based upon the research accomplished in this study. Incorporating sea-steaming timelines and costs would have a beneficial impact on the velocity with which intermodal operations may be considered for utilization. Early awareness and notification is critical to allow the mobilization and multi-modal transport required to utilize the capabilities and efficiencies of sealift.

By assessing the costs associated with steaming time compared to longer or shorter airlift sorties, there may be more utility for planners when analyzing intermodal port pairs. Assessing what factors to include for cost is a major area for further research. Costs to be considered include airlift in number of aircraft dedicated to the operation and ton-mile costs, sea steaming distance considerations, as well as port leasing and airfield access charges all can impact the overall transloading port pair decision. And the appropriate weighting to consider for the cost criteria when incorporating it within the suitability model may require additional AHP with theater logistical planners and TRANSCOM.

Additionally, this research considered only the strategic lift concept: C-17 and C-5 capability dictated suitability. The infrastructure in South America is far less robust than CENTCOM or distance constrained as in PACOM. Considerations for what may be moved or delivered by tactical airlift aircraft, C-130 or C-27, and then assessing airfield suitability with respect to all those aircraft should be researched. This has benefits for both SOUTHCOM and AFRICOM theaters; especially considering the lack of forward basing for each of those combatant commanders.

The dearth of current seaport and airfield surveys, especially of locations south of the equator in SOUTHCOM is detrimental to effective planning. Research may be conducted on the appropriate currency interval or means of automated updating of those surveys. This can aid in data currency and relevancy. Without accurate data, planning or assumptions may be in grave error. Simply because there have not been operations recently in those areas does not mean that planners should neglect their focus or awareness of them. In concert with accurate survey of worldwide infrastructure, considerate research and planning on where to focus efforts of improvements should be accomplished. In identifying locations in need of improvement to boost their relative capability ratings, combatant commanders can apply Building Partnership Capacity focus as well as inter-agency elements of power: diplomatic, intelligence, and economic if the countries are considered strategically important to ensure intermodal access. In the same vein, those most capable identified locations can be studied for long-term sustainment or infrastructure improvements to keep that capability for the host nation, as well as US use.

Final Thoughts

Sea-air intermodal transport offers unique capabilities for the military logistician. Utilizing it effectively based on sound operational planning provides the greatest opportunity to be efficient with the limited funds available to support worldwide commitments. The use of TRANSCOM's suitability model to identify seaport and airfield pairs to conduct transloading from sea to air shipment is one piece of that planning puzzle. It is a simple but effective model that covers important and well established transportation components: accessibility, capability, time, and security. Using the existing tool generates the most capable locations to support combatant commanders' options. Incorporating factors for reliability can aid military planners in improving the model for long-term use. By academic literature backing and use of an experimental model, this research proposed options for the best seaport and airfield pairs to support operations in a land-locked country in South America. Military planners can confidently use the model in the future to solve similar problems anywhere in the world.

Glossary

AFRICOM – United States African Command

AHP – Analytic Hierarchy Program

AMC – Air Mobility Command

AOR – Area of Responsibility

APOD – Aerial Port of Debarkation

ASRR – Airfield Suitability and Restrictions Report

CAST – Conflict Assessment System Tool

CJCS – Chairman of the Joint Chiefs of Staff

CRE – Contingency Response Element

DOD – Department of Defense

DPO – Distribution Process Owner

FOB – Forward Operating Base

FOUO – For Official Use Only

FSS – Fast Sealift Ship

GRP – Graduate Research Project

HADR – Humanitarian Assistance / Disaster Relief

IRRIS – Intelligent Road/Rail Information System

JDPAC – Joint Distribution Process Analysis Center

JTF-PO – Joint Task Force-Port Opening

LMSR – Large, Medium Speed Roll-On/Roll-Off

M-ATV – MRAP All-Terrain Vehicles

MRAP – Mine-Resistant Ambush-Protected Vehicles

MOG – Maximum On Ground

PACOM – United States Pacific Command

S3 – Operations

SDDC – Surface Deployment and Distribution Command

SOUTHCOM – United States Southern Command

STPD – Short Tons Per Day

TACC – Tanker Airlift Control Center

TEA – Transportation Engineering Agency

TEU – Twenty-foot Equivalent Unit

TRANSCOM – United States Transportation Command

US – United States

USSC – United States Southern Command

USTC – United States Transportation Command

Appendix A – 2010 Failed States Index

Country	Rank	Total	Demographic Pressures	Refugees and IDPs	Group Grievance	Human Flight	Uneven Economic Development	Economic Decline	Delegitimization of the State	Public Services	Human Rights	Security Apparatus	Factionalized Elites	External Intervention
Somalia	1	114.3	9.6	10	9.7	8.3	8.0	9.6	10	9.6	9.9	10	10	9.6
Chad	2	113.3	9.4	9.5	9.8	8.3	9.3	8.5	9.9	9.6	9.6	9.9	9.8	9.7
Sudan	3	111.8	8.8	9.8	9.9	8.7	9.5	6.7	9.9	9.3	9.9	9.8	9.9	9.6
Zimbabwe	4	110.2	9.4	8.6	8.8	9.7	9.4	9.6	9.6	9.4	9.5	9.2	9.5	7.5
Dem. Rep. of the Congo	5	109.9	9.9	9.6	8.6	8.0	9.5	8.7	8.8	9.0	9.4	9.8	8.9	9.7
Afghanistan	6	109.3	9.5	9.2	9.7	7.2	8.2	8.3	10	8.9	9.2	9.7	9.4	10
Iraq	7	107.3	8.5	8.7	9.3	9.3	8.8	7.6	9.0	8.4	9.1	9.5	9.6	9.5
Cen. African Rep.	8	106.4	9.1	9.3	8.9	6.1	9.2	8.4	9.0	9.2	8.8	9.7	9.1	9.6
Guinea	9	105.0	8.3	7.5	8.2	8.6	8.7	8.9	9.8	9.0	9.5	9.4	9.3	7.8
Pakistan	10	102.5	8.1	8.9	9.4	7.9	8.4	6.2	8.9	7.3	8.9	9.7	9.5	9.3
Haiti	11	101.6	9.3	5.6	7.3	8.6	8.3	9.2	9.3	9.5	8.3	8.2	8.4	9.6
Ivory Coast	12	101.2	8.4	8.0	8.9	8.2	7.9	8.0	9.0	8.3	8.3	8.2	8.5	9.5
Kenya	13	100.7	9.1	8.7	8.9	7.9	8.7	7.4	9.3	8.1	8.0	7.5	8.7	8.4
Nigeria	14	100.2	8.4	5.8	9.5	8.1	9.3	6.9	9.4	9.1	8.8	9.3	9.4	6.2
Yemen	15	100.0	8.6	8.3	8.2	7.2	8.6	7.9	8.7	8.6	8.0	8.9	9.2	7.8
Burma	16	99.4	8.5	8.3	8.7	6.3	9.3	8.2	9.6	8.5	9.1	8.2	8.2	6.5
Ethiopia	17	98.8	9.2	7.8	8.6	7.5	8.5	8.0	7.7	8.1	8.7	7.8	9.0	7.9
East Timor	18	98.2	8.6	9.1	7.5	6.1	7.0	8.4	9.1	8.7	7.0	8.8	8.7	9.2
North Korea	19	97.8	8.5	5.6	7.2	5.0	8.8	9.6	9.9	9.6	9.5	8.1	7.8	8.2
Niger	19	97.8	9.6	6.5	8.0	6.5	7.8	9.2	8.9	9.7	8.5	7.3	7.6	8.2
Uganda	21	97.5	8.7	8.9	8.5	6.9	8.4	7.2	7.9	8.2	7.6	8.7	8.6	7.9
Guinea-Bissau	22	97.2	8.5	6.8	5.8	7.1	8.4	8.3	9.1	8.8	8.1	8.9	8.9	8.5
Burundi	23	96.7	9.4	8.4	7.8	6.5	8.4	8.2	7.6	9.0	7.7	7.1	7.9	8.7
Bangladesh	24	96.1	8.4	6.7	8.9	8.4	8.8	7.9	8.0	8.3	7.4	8.1	8.9	6.3
Sri Lanka	25	95.7	7.3	9.4	9.6	6.7	8.7	5.9	8.6	6.4	8.8	8.5	9.4	6.4
Nepal	26	95.4	8.1	7.0	9.2	6.2	9.0	8.3	8.1	7.6	8.7	7.7	8.5	7.0
Cameroon	26	95.4	8.2	7.6	7.5	8.1	8.7	7.0	9.0	8.0	7.8	7.8	8.7	7.0
Malawi	28	93.6	9.2	6.5	6.2	8.4	8.3	9.2	8.1	8.6	7.3	5.4	7.8	8.6
Sierra Leone	28	93.6	9.1	7.1	6.7	8.3	8.8	8.6	7.7	9.1	6.8	5.9	7.8	7.7
Eritrea	30	93.3	8.7	7.2	6.1	7.1	6.2	8.6	8.8	8.6	8.4	7.6	7.9	8.1
Rep. of the Congo	31	92.5	8.7	7.7	6.3	6.4	8.1	7.8	9.1	8.6	7.7	7.6	7.1	7.4
Iran	32	92.2	6.4	8.3	8.1	7.1	7.3	5.5	9.0	5.9	9.4	8.9	9.5	6.8
Liberia	33	91.7	8.4	8.2	6.3	6.7	8.3	8.0	7.1	8.5	6.5	6.7	8.1	8.9
Lebanon	34	90.9	6.8	8.9	9.0	7.0	7.2	6.1	7.3	6.0	6.8	8.9	8.8	8.1
Burkina Faso	35	90.7	9.3	6.2	5.9	6.6	8.8	8.0	7.7	8.8	6.6	7.3	7.6	7.9

Country	Rank	Total	Demographic Pressures	Refugees and IDPs	Group Grievance	Human Flight	Uneven Economic Development	Economic Decline	Delegitimization of the State	Public Services	Human Rights	Security Apparatus	Factionalized Elites	External Intervention
Uzbekistan	36	90.5	7.7	5.1	7.4	6.6	8.5	7.0	8.5	6.4	9.3	8.8	9.0	6.2
Georgia	37	90.4	6.2	7.8	8.4	5.8	7.2	6.5	9.0	6.4	7.3	8.0	9.1	8.7
Tajikistan	38	89.2	8.0	6.2	6.9	6.3	7.1	7.5	8.9	7.3	8.7	7.3	8.4	6.6
Mauritania	39	89.1	8.5	6.4	8.0	5.2	6.8	7.7	7.5	8.3	7.3	7.9	7.9	7.6
Laos	40	88.7	7.9	5.9	6.8	6.7	5.8	7.3	8.3	8.1	8.7	7.4	8.5	7.3
Rwanda	40	88.7	9.1	7.0	8.5	7.0	7.2	7.0	7.5	7.4	7.5	5.0	8.0	7.5
Cambodia	40	88.7	8.0	5.3	6.9	7.9	7.1	7.7	8.7	8.3	7.7	6.4	7.7	7.0
Solomon Islands	43	88.6	8.3	4.8	7.0	5.4	7.9	8.0	8.1	8.2	6.8	7.0	8.0	9.1
Equatorial Guinea	44	88.5	8.4	2.3	6.8	7.4	8.8	4.7	9.6	8.4	9.4	8.4	8.4	5.9
Kyrgyzstan	45	88.4	7.8	5.2	7.4	7.3	7.9	7.9	8.4	6.3	7.6	7.6	7.4	7.6
Colombia	46	88.2	6.7	9.0	7.2	8.3	8.3	4.6	7.7	5.8	6.9	7.7	8.0	8.0
Togo	47	88.1	8.0	6.2	5.6	7.0	7.6	8.0	7.5	8.4	7.7	7.6	7.6	6.9
Syria	48	87.9	5.9	8.9	8.3	6.6	7.8	6.3	8.6	5.5	8.8	7.6	7.8	5.8
Egypt	49	87.6	7.4	6.7	8.2	6.0	7.4	6.8	8.4	6.1	8.2	6.5	8.1	7.8
Bhutan	50	87.3	7.0	7.3	7.7	7.1	8.5	7.5	6.9	7.3	7.9	5.8	7.7	6.6
Philippines	51	87.1	7.7	6.7	7.6	7.0	7.4	5.8	8.6	6.3	7.5	7.9	8.0	6.6
Comoros	52	85.1	7.5	3.9	5.6	6.4	6.1	7.6	8.2	8.5	6.8	7.5	8.0	9.0
Bolivia	53	84.9	7.6	4.7	7.7	6.7	8.7	6.8	7.1	7.5	6.6	6.5	8.3	6.7
Israel/West Bank	54	84.6	7.0	7.8	9.5	3.8	7.7	4.4	7.3	6.8	7.8	6.5	8.2	7.8
Azerbaijan	55	84.4	6.2	8.1	7.9	5.7	7.3	5.9	8.0	5.5	7.2	7.3	7.9	7.4
Zambia	56	83.9	9.0	7.3	5.4	7.1	7.3	8.0	7.5	8.0	5.9	5.0	6.1	7.3
Papua New Guinea	56	83.9	7.5	4.2	7.1	7.7	9.0	6.3	7.8	8.3	6.3	6.5	7.1	6.1
Moldova	58	83.8	6.4	4.3	6.9	7.8	6.8	7.0	7.9	6.7	6.8	7.8	8.0	7.4
Angola	59	83.7	8.4	6.9	5.9	5.6	9.1	5.0	8.1	8.0	7.3	5.9	6.8	6.7
Bosnia and Herzegovina	60	83.5	5.3	7.1	8.7	5.6	7.1	5.7	8.0	5.4	5.9	7.2	9.2	8.3
Indonesia	61	83.1	7.2	6.5	6.3	7.3	7.9	6.7	6.9	6.7	6.5	7.3	7.1	6.7
China	62	83.0	8.8	6.6	8.0	5.9	9.0	4.3	8.3	7.0	9.0	5.8	7.2	3.1
Swaziland	63	82.8	9.1	4.2	4.2	6.2	6.2	8.2	8.6	7.6	7.7	6.6	6.9	7.3
Madagascar	64	82.6	8.6	4.8	5.4	5.3	7.7	7.2	7.1	8.6	5.8	6.4	7.7	8.0
Turkmenistan	65	82.5	6.8	4.6	6.3	5.4	7.4	6.6	8.4	7.0	9.0	7.7	7.7	5.6
Nicaragua	65	82.5	6.8	5.0	6.3	6.9	7.9	7.9	7.6	7.6	6.2	6.5	7.0	6.8
Lesotho	67	82.2	9.2	4.8	5.2	6.7	5.7	8.7	7.2	8.5	6.3	5.9	7.2	6.8
Djibouti	68	81.9	7.9	6.8	5.9	5.5	6.5	6.4	7.2	7.3	6.6	6.0	7.1	8.7
Ecuador	69	81.7	6.3	6.1	6.4	7.5	8.0	6.7	7.4	7.0	5.8	6.6	7.8	6.1
Mozambique	69	81.7	8.8	3.5	4.8	7.8	7.5	7.8	7.5	8.9	7.3	6.2	5.4	6.2
Algeria	71	81.3	6.7	6.5	8.2	6.1	7.1	5.1	7.5	6.5	7.6	7.5	6.8	5.7
Tanzania	72	81.2	8.2	7.3	6.4	6.1	6.7	7.2	6.5	8.3	5.9	5.6	6.0	7.0

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Guatemala	72	81.2	7.4	5.6	6.8	6.7	8.0	6.9	7.1	6.8	6.9	7.2	6.3	5.5
Fiji	74	80.5	5.9	4.2	7.4	6.6	7.5	6.7	8.9	5.5	6.7	6.8	8.2	6.1
Gambia	75	80.2	7.6	6.0	4.6	6.2	6.8	7.5	7.6	7.2	7.4	5.8	6.2	7.3
Honduras	76	80.0	7.6	4.1	5.0	6.5	8.3	7.5	7.5	6.9	6.3	7.0	6.8	6.5
Cuba	77	79.4	6.7	5.7	5.5	7.2	6.6	6.3	7.0	5.0	7.5	7.3	7.1	7.5
Mali	78	79.3	8.7	4.8	6.3	7.5	7.0	8.1	5.4	8.5	5.0	7.0	4.0	7.0
India	79	79.2	8.1	5.2	7.8	6.5	8.7	5.1	5.8	7.2	6.1	7.6	6.2	4.9
Russia	80	79.0	6.7	5.4	7.1	6.0	7.9	5.1	8.1	5.5	8.0	6.8	7.6	4.8
Thailand	81	78.8	6.7	6.7	7.8	4.7	7.5	4.3	8.0	5.4	7.0	7.4	8.0	5.3
Belarus	82	78.7	6.7	3.7	6.4	4.8	6.7	6.7	8.7	6.2	7.9	6.2	7.8	6.9
Venezuela	82	78.7	6.3	5.1	6.8	6.7	7.6	5.8	7.2	6.1	7.2	6.7	7.5	5.7
Maldives	84	78.3	6.3	6.4	5.2	7.1	5.3	7.0	7.3	7.1	7.3	6.1	7.4	5.8
El Salvador	85	78.1	8.1	5.7	5.9	7.1	7.9	6.6	6.8	7.0	6.7	6.7	4.5	5.1
Serbia/Kosovo	86	77.8	5.6	6.9	7.8	5.3	6.9	6.2	6.8	5.2	5.6	6.5	8.0	7.0
Saudi Arabia	87	77.5	6.3	6.2	7.8	3.5	7.3	3.1	8.2	4.1	9.1	7.8	7.8	6.3
Cape Verde	88	77.2	7.7	4.1	4.4	8.2	6.0	7.0	7.2	7.4	6.0	5.5	6.1	7.6
Turkey	89	77.1	6.3	6.3	8.0	4.8	7.8	5.8	6.0	5.4	5.5	7.4	7.8	6.0
Jordan	90	77.0	6.8	7.9	6.9	4.8	7.2	6.2	5.9	5.2	7.0	5.9	6.5	6.7
Morocco	90	77.0	6.8	6.6	6.6	6.4	7.6	6.5	7.2	6.6	6.8	5.4	6.2	4.3
Peru	92	76.9	6.4	4.5	6.7	7.0	8.0	5.6	6.9	6.5	5.5	7.4	6.9	5.5
Dominican Republic	93	76.8	6.5	5.1	5.8	8.3	7.8	5.9	5.6	6.9	6.5	5.6	6.8	6.0
Benin	93	76.8	7.7	6.7	4.2	6.7	7.4	7.4	6.4	8.4	5.5	5.3	4.1	7.0
Vietnam	95	76.6	6.9	5.2	5.3	5.9	6.5	6.6	7.3	6.4	7.3	6.0	7.0	6.2
Mexico	96	76.1	6.8	4.1	5.8	6.8	8.0	6.5	6.6	5.8	5.8	7.5	5.5	6.9
Sao Tome	97	75.8	7.5	4.1	5.1	7.0	5.9	7.3	7.3	7.3	5.1	6.0	6.7	6.5
Gabon	98	75.3	7.0	5.9	3.0	6.4	7.9	5.9	7.8	6.6	6.4	5.7	7.2	5.5
Senegal	99	74.6	7.6	6.2	6.1	5.8	7.0	6.2	5.9	7.4	6.0	6.3	4.2	5.9
Namibia	100	74.5	7.5	5.7	5.6	7.5	8.9	6.5	4.8	6.9	5.8	5.6	3.7	6.0
Armenia	101	74.1	5.7	6.9	6.0	7.0	6.5	5.8	6.6	5.3	6.4	5.1	7.0	5.8
Guyana	102	73.0	6.1	3.6	6.2	8.0	7.7	6.9	6.8	5.3	5.2	6.6	5.1	5.5
Macedonia	103	72.7	4.8	4.6	7.6	6.7	7.1	6.6	6.9	4.6	5.1	5.6	6.5	6.6
Kazakhstan	103	72.7	5.8	4.0	5.7	4.1	6.2	6.7	7.5	5.5	7.1	6.3	7.6	6.2
Suriname	105	72.5	6.0	3.7	6.4	6.7	7.7	6.6	6.5	5.1	5.8	6.0	5.8	6.2
Paraguay	106	72.1	6.2	1.5	6.3	5.8	8.0	6.2	8.3	5.8	6.7	5.9	7.5	3.9
Samoa	107	71.1	6.9	3.1	5.1	8.0	6.6	6.2	6.4	5.1	4.5	5.8	5.3	8.1
Micronesia	108	70.6	7.0	3.1	4.5	8.1	6.8	6.4	6.6	6.6	2.8	5.1	5.5	8.1
Ukraine	109	69.5	5.6	3.1	6.9	6.6	6.2	6.3	7.2	4.0	5.3	3.8	7.9	6.6

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Malaysia	110	69.2	6.3	5.0	6.6	3.9	7.0	5.1	5.9	5.0	6.8	5.9	6.3	5.4
Libya	111	69.1	5.7	4.3	5.8	4.2	6.9	5.3	7.3	4.2	8.3	5.2	7.1	4.8
Belize	112	68.7	6.5	5.1	4.9	6.7	7.1	6.2	6.2	5.8	3.8	5.7	4.6	6.1
Botswana	113	68.6	9.0	6.6	4.1	5.9	7.7	6.1	5.3	6.4	4.8	4.0	2.9	5.8
Cyprus	114	68.0	4.8	4.5	7.6	5.0	7.6	4.3	5.2	3.4	3.6	5.3	7.9	8.8
Seychelles	115	67.9	6.1	4.3	5.0	4.5	6.9	5.8	7.0	4.5	5.9	5.6	6.0	6.3
South Africa	115	67.9	8.4	7.0	5.6	4.4	8.5	5.0	5.8	5.5	4.7	4.1	5.9	3.0
Brunei Darussalam	117	67.6	5.4	4.2	6.6	3.8	7.8	3.7	7.7	3.5	6.9	5.9	7.4	4.7
Tunisia	118	67.5	5.7	3.4	5.4	5.2	7.0	5.0	6.4	5.7	7.5	6.5	6.0	3.7
Brazil	119	67.4	6.3	3.7	6.2	4.8	8.8	4.0	6.2	6.0	5.4	6.7	5.1	4.2
Jamaica	119	67.4	6.0	2.8	4.5	6.4	6.5	6.8	6.8	6.2	5.5	5.8	4.0	6.1
Albania	121	67.1	5.9	2.8	4.9	7.1	5.7	6.1	6.8	5.6	5.3	5.4	6.0	5.5
Ghana	122	67.1	7.1	5.3	5.2	7.9	6.4	5.8	5.1	7.6	4.7	2.6	4.2	5.2
Grenada	123	67.0	5.8	2.9	4.2	7.6	6.7	6.1	6.4	3.9	4.6	5.4	5.8	7.6
Trinidad and Tobago	124	66.1	5.6	3.1	4.9	7.3	7.2	4.8	5.9	5.2	5.4	6.0	5.6	5.1
Kuwait	125	61.5	5.5	4.1	5.1	4.1	6.1	3.8	6.0	3.1	6.5	4.9	7.2	5.1
Bulgaria	126	61.2	4.5	3.9	4.5	5.8	6.1	5.3	6.0	5.0	4.6	5.1	4.6	5.8
Antigua and Barbuda	127	60.9	4.7	3.4	4.5	7.3	6.1	5.5	5.3	4.6	4.7	4.6	4.0	6.2
Romania	128	60.2	5.4	3.2	5.6	4.9	5.6	5.6	6.0	4.8	4.3	4.1	5.2	5.5
Mongolia	129	60.1	5.6	1.4	4.3	2.3	5.9	5.7	6.2	5.3	6.4	4.8	5.3	6.9
Panama	130	59.3	6.3	3.5	4.4	5.0	7.5	5.6	4.8	5.5	4.5	5.2	3.0	4.0
Croatia	131	59.0	4.7	5.9	5.2	4.6	5.3	6.2	4.8	3.7	4.5	4.4	4.3	5.4
Bahamas	132	58.9	6.2	3.2	4.7	5.8	6.4	5.0	5.5	4.4	2.8	4.8	4.8	5.3
Bahrain	133	58.8	4.5	2.6	6.5	3.5	6.0	4.0	6.7	3.1	5.4	4.7	6.1	5.7
Montenegro	134	57.3	4.9	4.2	6.6	2.7	4.4	4.9	4.5	3.8	5.3	4.5	5.9	5.6
Barbados	135	55.4	4.0	3.2	4.9	6.5	6.7	5.4	4.1	3.1	2.8	4.5	4.5	5.7
Latvia	135	55.4	4.3	4.3	4.6	5.0	6.0	6.3	5.4	4.2	3.5	3.0	4.3	4.5
United Arab Emirates	137	52.4	4.4	3.2	4.7	3.3	5.7	3.9	6.7	3.4	5.9	2.7	4.0	4.5
Costa Rica	138	52.0	5.5	4.6	3.9	4.5	6.5	5.4	3.9	4.1	3.3	2.5	3.2	4.6
Qatar	139	51.8	4.5	3.0	5.2	3.4	5.3	4.1	6.3	2.6	4.7	2.7	5.0	5.0
Estonia	140	50.7	4.5	4.2	5.0	4.1	5.2	5.0	4.5	3.3	3.3	2.6	5.5	3.5
Hungary	141	50.1	3.3	3.1	3.2	4.8	5.9	5.4	5.7	3.6	3.3	2.2	5.0	4.6
Poland	142	49.0	4.7	3.2	3.3	5.9	4.8	5.0	4.5	3.7	3.8	2.4	3.7	4.0
Slovakia	143	48.8	4.1	2.2	4.8	5.2	5.6	5.0	4.1	3.8	3.8	2.1	3.9	4.2
Oman	144	48.7	4.7	1.1	3.0	1.7	2.7	4.5	6.0	4.5	6.7	5.2	6.6	2.0
Malta	145	48.2	3.7	5.8	4.2	4.1	4.4	4.2	4.1	3.2	3.7	4.0	2.0	4.8

Country	Rank	Total	Demographic Pressures	Refugees and IDPs	Group Grievance	Human Flight	Uneven Economic Development	Economic Decline	Delegitimization of the State	Public Services	Human Rights	Security Apparatus	Factionalized Elites	External Intervention
Lithuania	146	47.8	4.3	2.9	4.0	5.0	6.0	5.7	3.9	3.2	3.3	2.2	3.2	4.1
Greece	147	45.9	4.5	2.8	4.2	4.5	4.6	4.3	4.6	3.7	3.4	3.4	2.4	3.5
Argentina	148	45.8	4.6	2.2	4.5	3.8	5.8	5.1	3.6	3.7	3.8	2.4	3.2	3.1
Italy	149	45.7	4.0	3.9	4.8	2.8	4.5	4.7	4.5	3.1	3.0	4.2	4.0	2.2
Mauritius	150	44.4	3.7	1.2	3.5	2.6	5.7	4.1	5.1	4.2	3.7	3.7	3.3	3.6
Spain	151	43.5	3.7	2.8	6.3	1.8	5.0	4.4	1.6	2.4	2.5	5.3	5.7	2.0
Czech Republic	152	41.5	3.3	2.8	3.4	4.3	4.1	4.4	3.4	3.6	3.3	2.1	3.3	3.5
South Korea	153	41.3	3.6	3.3	3.9	4.8	2.5	2.8	3.9	2.3	2.8	1.5	3.6	6.3
Uruguay	153	41.3	4.3	1.3	2.0	5.6	5.0	4.0	2.6	3.4	2.5	3.4	3.0	4.2
Chile	155	38.0	4.1	2.6	3.4	2.5	4.5	4.6	1.8	4.0	3.4	2.3	1.5	3.3
Slovenia	156	36.0	3.4	1.4	3.4	3.3	5.0	4.0	2.8	3.0	3.0	2.8	1.3	2.6
Germany	157	35.4	3.3	4.0	4.7	2.6	4.7	3.6	2.1	1.7	2.3	2.2	2.0	2.2
United States	158	35.3	3.1	3.2	3.4	1.1	5.4	4.0	2.5	2.5	3.7	1.6	3.3	1.5
France	159	34.9	3.7	3.1	5.6	1.8	5.3	3.6	1.8	1.5	2.7	1.6	2.0	2.2
Singapore	160	34.8	2.8	0.9	2.9	2.5	3.1	3.7	4.2	1.7	4.4	1.5	4.1	3.0
United Kingdom	161	33.9	3.2	3.0	4.1	1.8	4.5	3.0	1.6	2.3	2.3	2.7	3.2	2.2
Portugal	162	33.1	3.7	1.8	2.6	2.2	3.7	4.7	1.9	3.6	3.5	1.4	1.2	2.8
Belgium	163	32.0	2.6	1.8	4.4	1.3	4.7	3.7	2.3	2.1	1.5	1.8	3.0	2.8
Japan	164	31.3	4.0	1.2	3.6	2.1	2.6	3.5	1.8	1.3	3.2	2.1	2.2	3.7
Iceland	165	29.8	0.8	1.1	1.0	3.0	2.3	7.2	2.0	1.5	1.9	1.1	2.0	5.9
Canada	166	27.9	3.2	2.5	3.1	2.1	4.5	2.5	1.5	1.5	1.9	1.2	2.4	1.5
Netherlands	166	27.9	2.7	3.2	4.7	1.9	3.2	3.0	1.2	1.5	1.3	1.1	1.7	2.4
Luxembourg	168	27.3	1.9	1.7	3.2	1.2	2.3	2.8	2.7	2.2	1.3	2.1	3.6	2.3
Australia	168	27.3	3.5	2.5	3.4	1.2	4.2	3.2	1.5	1.8	2.0	1.4	1.5	1.1
Austria	170	27.2	2.7	2.3	3.8	1.2	4.7	2.7	1.4	1.4	1.6	1.1	1.9	2.4
New Zealand	171	23.9	1.5	1.4	3.3	2.1	4.3	4.0	1.0	1.6	1.5	1.1	1.2	0.9
Denmark	172	22.9	2.8	1.7	3.0	1.8	2.0	3.1	1.1	1.3	1.3	1.5	1.0	2.3
Ireland	173	22.4	2.0	1.6	1.0	2.0	2.8	3.3	1.6	2.4	1.5	1.4	1.5	1.3
Switzerland	174	21.8	2.4	1.5	3.3	1.8	2.6	2.4	1.0	1.4	2.2	1.2	1.0	1.0
Sweden	175	20.9	2.7	2.7	1.3	1.8	2.1	2.2	0.8	1.3	1.8	1.3	1.3	1.6
Finland	176	19.3	2.3	1.7	1.2	2.2	1.7	3.0	0.7	1.2	1.5	1.0	1.0	1.8
Norway	177	18.7	1.7	1.6	1.3	1.2	2.4	2.6	0.8	1.1	1.6	1.2	1.1	2.1

(Fund for Peace, 2010)

Notes: Red – Alert Orange – Warning Yellow – Moderate Green – Stable

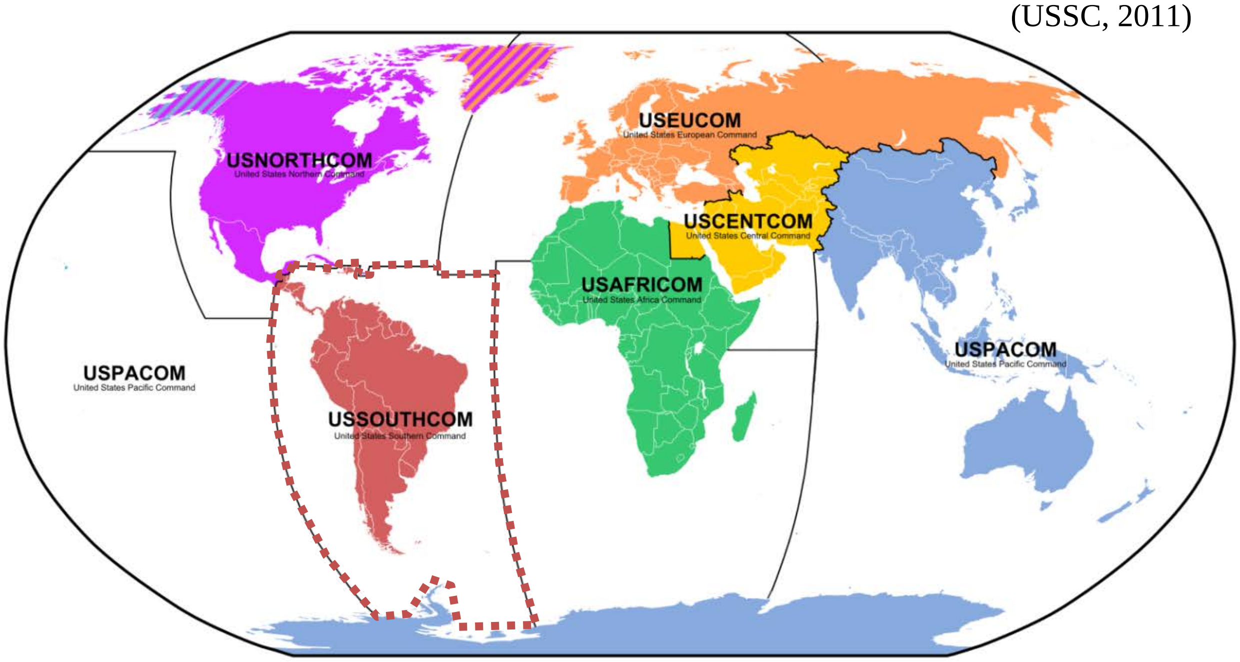
Appendix B – SOUTHCOM AOR and Countries

The U.S. Southern Command Area of Responsibility encompasses 31 countries and 10 territories. The region represents about one-sixth of the landmass of the world assigned to regional unified commands.

SOUTHCOM´s Area of Responsibility includes:

The land mass of Latin America south of Mexico, The waters adjacent to Central and South America, The Caribbean Sea, A portion of the Atlantic Ocean.

(USSC, 2011)



Antigua and Barbuda
Argentina
Barbados
Belize
Bolivia
Brazil
Cayman Islands
Chile
Colombia
Costa Rica
Dominica
Dominican Republic
Ecuador
El Salvador
Grenada
Guatemala
Guyana
Haiti
Honduras
Jamaica
Nicaragua
Panama
Paraguay
Peru
St Kitts and Nevis
St Vincent and the Grenadines
St Lucia
Suriname
Trinidad and Tobago
Uruguay
Venezuela

Appendix C – TRANSCOM Suitability Model Criteria Definitions
(Alderman, 2011)

UNCLASSIFIED

Constraints/Assumptions/Planning Factors

Constraints
- No fuel loading in Afghanistan

Assumptions
- Countries allow access to ports and airfields (geo-political issues not addressed in this assessment)
- Equal weighting of all criteria
- Non-extended range C-17s
- Port suitability based on largest class of LMSR/FSSs
- Fuel available at multi modal airfield
- Over flight of Turkmenistan

Planning Factors
- MOG calculations based on C-17 wingspan plus 25 feet between wing tips or edge of apron, when not found in literature search
- 17 hour flight crew duty day with no augmentation
- 40 short ton cargo load for C-17s
- one hour ground time in Afghanistan, burning 5K pounds of fuel

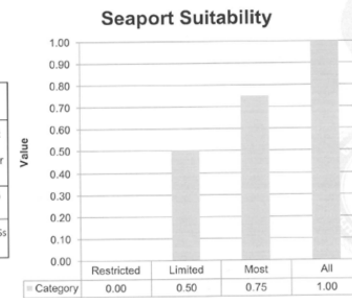
UNCLASSIFIED

17

UNCLASSIFIED

Criteria Definition and Value Function

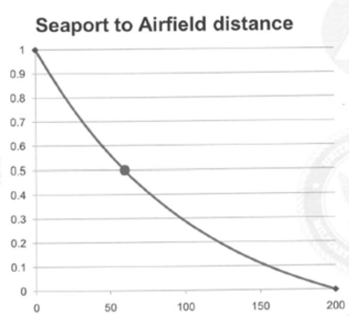
1.00	All	the seaport is capable of receiving multiple ships of the largest class of LMSR/FFS fully loaded
0.75	Most	the seaport is capable of receiving multiple ships with at least one of the berths supporting a fully loaded Cape D LMSR/FSS and other berths supporting smaller classes or lighting loaded Cape Ds
0.50	Limited	the seaport is capable of receiving lightly loaded CAPE D LMSR/FSSs
0.00	Restricted	the seaport is not capable of receiving CAPE D LMSR/FSSs due to draft or length restrictions



UNCLASSIFIED

Criteria Definition and Value Function

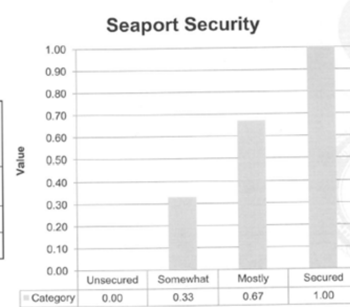
1.00	Number of miles (one way)	Seaport and airport co-located
0.50		up to 60 miles from the seaport to the airport
0.00		over 200 miles



UNCLASSIFIED

Criteria Definition and Value Function

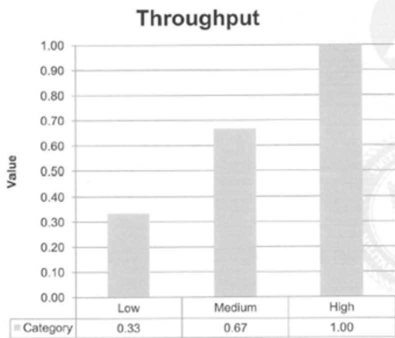
1.00	Secured	fencing/walls around perimeter with controlled access points manned by armed guards with surveillance or roving patrols with the capability (to further restrict access) to provide additional security for berths being used for US operations. ISPS compliant
0.67	Mostly secured	perimeter fencing with controlled access points by unarmed guards with no restrictions on movement once inside the port
0.33	Somewhat secured	open port with secured areas within the port, such as cargo yards
0.00	unsecured	open port with no perimeter fencing and/or controlled access points



UNCLASSIFIED

Criteria Definition and Value Function

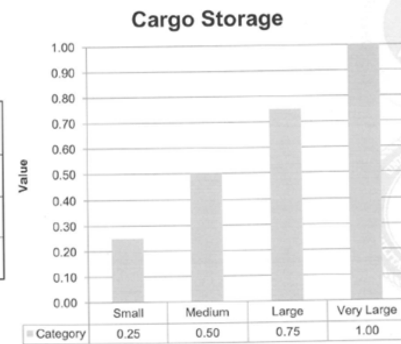
1.00	High	greater than 1,000 TEUs/day (10,000 STPD) for containers or greater than 500 pieces for RORO
0.67	Medium	between 500 and 1,000 TEUs/day (5,000 to 10,000 STPD) for containers or 200 to 500 pieces of equipment for RORO
0.33	Low	less than 500 TEUs per day (5,000 STPD) for containers or less than 200 pieces of equipment for RORO



UNCLASSIFIED

Criteria Definition and Value Function

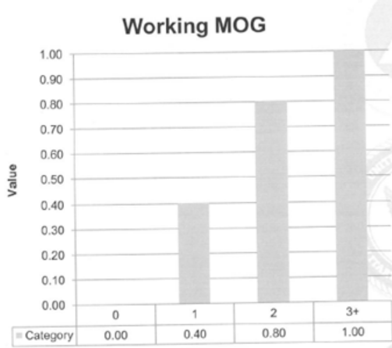
1.00	Very Large	very large cargo storage areas (over 2 million square feet) on-site and additional off-site cargo storage areas nearby
0.75	Large	large cargo storage areas (1-2 million square feet) on-site and additional off-site cargo storage areas
0.50	Medium	less than a million square feet of cargo storage area on-site and additional off-site cargo storage areas
0.25	Small	less than a million square feet of cargo storage area on-site and no additional off-site cargo storage areas



UNCLASSIFIED

Criteria Definition and Value Function

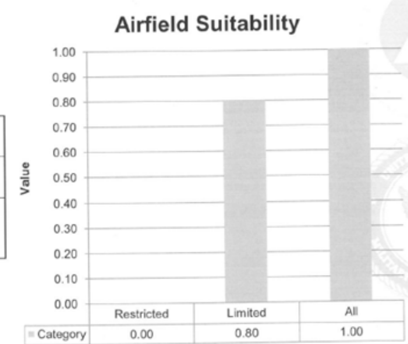
1.00	3+
0.80	2
0.40	1
0.00	0



UNCLASSIFIED

Criteria Definition and Value Function

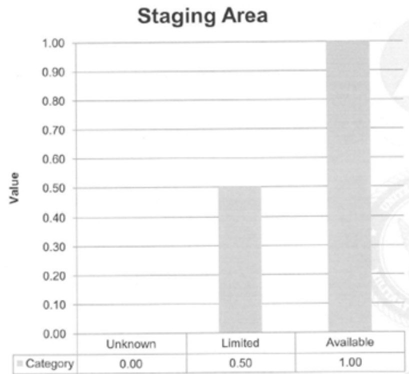
1.00	All	Airfield is C5 capable to include parking ramps
0.80	Limited	Airfield is C17 capable to include parking ramps
0.00	Restricted	Does not support aircraft larger than C-130 or commercial equivalent



UNCLASSIFIED

Criteria Definition and Value Function

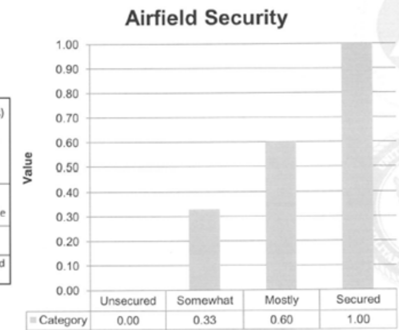
1.00	Available
0.50	Limited
0.00	Unknown



UNCLASSIFIED

Criteria Definition and Value Function

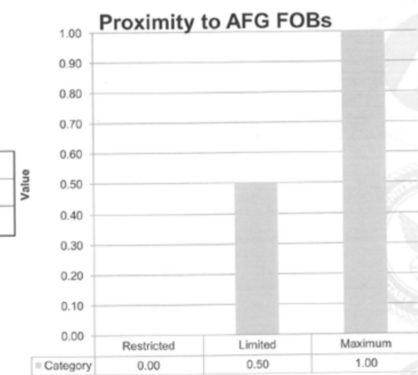
1.00	Secured	fencing/walls around perimeter (to include guard towers) with controlled access points manned by armed guards with surveillance or roving patrols with the capability (to further restrict access) to provide additional security for ramps being used for US operations
0.67	Mostly secured	perimeter fencing with controlled access points, roving patrols and limited restrictions on movement once inside
0.33	Somewhat secured	open airfield with secured areas within the airfield, such as flight line
0.00	unsecured	open airfield with no perimeter fencing and/or controlled access points



UNCLASSIFIED

Criteria Definition and Value Function

1.00	Maximum	Multi turns for C17s with no refueling in Afghanistan
0.50	Limited	One turn for C17 with no refueling in Afghanistan
0.00	Restricted	One turn for C17 with a refueling requirement



Appendix D – Model Results

	TRANSCOM Original Model			Trial 1 - Equal Weights			Trial 2 - Failed States Scores (No Weighting)			Trial 3 - Failed States Index and Weighted Scores		
	Seaport	Country	Capability Rating	Seaport	Country	Capability Rating	Seaport	Country	Capability Rating	Seaport	Country	Capability Rating
1	Port of Montevideo †	Uruguay	0.802	Santos (Sau Paulo) †	Brazil	0.781	Port of Montevideo †	Uruguay	0.767	Port of Montevideo †	Uruguay	0.796
2	Santos (Sau Paulo) †	Brazil	0.796	Port of Montevideo †	Uruguay	0.777	Port of Balboa / Howard	Panama	0.753	Santos (Sau Paulo) †	Brazil	0.773
3	Port of Buenos Aires †	Argentina	0.758	Port of Balboa / Howard	Panama	0.761	Santos (Sau Paulo) †	Brazil	0.740	Port of Buenos Aires †	Argentina	0.754
4	Corinto / Managua Int'l	Nicaragua	0.753	Port of Buenos Aires †	Argentina	0.745	Port of Buenos Aires †	Argentina	0.738	San Antonio Port †	Chile	0.741
5	Astillero Naval, Sede Mamonal	Colombia	0.744	Corinto / Managua Int'l	Nicaragua	0.728	San Antonio Port †	Chile	0.714	Corinto / Managua Int'l	Nicaragua	0.733
6	San Antonio Port †	Chile	0.743	San Antonio Port †	Chile	0.718	Port of Bridgetown	Barbados	0.693	Port of Balboa / Howard	Panama	0.732
7	Port Haina	Dominican Republic	0.743	Port Haina	Dominican Republic	0.701	Corinto / Managua Int'l	Nicaragua	0.692	Astillero Naval, Sede Mamonal	Colombia	0.726
8	Port of Balboa / Howard	Panama	0.736	Port of Kingston	Jamaica	0.700	St Christopher (St Kitts Basseterre Roadsted)	St Kitts, W.I.	0.686	Port Haina	Dominican Republic	0.724
9	Port of Bridgetown	Barbados	0.724	Port of Bridgetown	Barbados	0.695	Port of Cristobal	Panama	0.673	Port of Bridgetown	Barbados	0.723
10	Port of Kingston	Jamaica	0.700	Astillero Naval, Sede Mamonal	Colombia	0.694	Port Haina	Dominican Republic	0.667	St Christopher (St Kitts Basseterre Roadsted)	St Kitts, W.I.	0.689
11	Nieuwe Haven Terminal, Paramaribo	Suriname	0.696	Nieuwe Haven Terminal, Paramaribo	Suriname	0.679	Port of Kingston	Jamaica	0.666	Port of Kingston	Jamaica	0.681
12	Port of Quetzal	Guatemala	0.684	Port of Cristobal	Panama	0.673	Astillero Naval, Sede Mamonal	Colombia	0.661	Nieuwe Haven Terminal, Paramaribo	Suriname	0.678
13	St Christopher (St Kitts Basseterre Roadsted)	St Kitts, W.I.	0.672	Port of Quetzal	Guatemala	0.659	Nieuwe Haven Terminal, Paramaribo	Suriname	0.647	Port of Quetzal	Guatemala	0.667
14	Port of Guayaquil	Ecuador	0.665	St Christopher (St Kitts Basseterre Roadsted)	St Kitts, W.I.	0.655	Port of Quetzal	Guatemala	0.629	Port of Guayaquil	Ecuador	0.649
15	Puerto Cortes	Honduras	0.663	Port of Guayaquil	Ecuador	0.648	Port of Guayaquil	Ecuador	0.619	Puerto Cortes	Honduras	0.648
16	Port of Spain	Trinidad, W.I	0.658	Port of Spain	Trinidad, W.I	0.642	Port of Spain	Trinidad, W.I	0.613	Chaguaramas	Trinidad, W.I	0.634
17	Chaguaramas	Trinidad, W.I	0.649	Puerto Cortes	Honduras	0.638	Puerto Cortes	Honduras	0.610	Port of Spain	Trinidad, W.I	0.634
18	Port of Quetzal	Guatemala	0.641	PORT OF PAITA	Peru	0.635	PORT OF PAITA	Peru	0.608	Woodbridge Bay Port / Melville Hall	Dominica	0.632
19	St. John's Harbour	Antigua, W.I.	0.637	Chaguaramas	Trinidad, W.I	0.633	Woodbridge Bay Port / Melville Hall	Dominica	0.605	Port of Quetzal	Guatemala	0.626
20	Port of St. Georges	Grenada	0.627	St. John's Harbour	Antigua, W.I.	0.628	Chaguaramas	Trinidad, W.I	0.605	Port of Cristobal	Panama	0.623
21	PORT OF PAITA	Peru	0.625	Port of Quetzal	Guatemala	0.626	St. John's Harbour	Antigua, W.I.	0.601	St. John's Harbour	Antigua, W.I.	0.622
22	Port of Cristobal	Panama	0.623	Corinto / Chinandega	Nicaragua	0.614	Port of Quetzal	Guatemala	0.599	Port of St. Georges	Grenada	0.615
23	Port International de Port-au-Prince	Haiti	0.621	Port International de Port-au-Prince	Haiti	0.597	Corinto / Chinandega	Nicaragua	0.589	PORT OF PAITA	Peru	0.610
24	Port of Ocho Rios	Jamaica	0.620	Port of Ocho Rios	Jamaica	0.589	Port of Balboa / Gelabert Int'l	Panama	0.578	Port of Ocho Rios	Jamaica	0.607
25	Port of Belize	Belize	0.615	Port of Belize	Belize	0.581	Port of Ocho Rios	Jamaica	0.563	Port of Belize	Belize	0.602
26	Woodbridge Bay Port / Melville Hall	Dominica	0.610	Puerto Bolivar, Machala	Ecuador	0.572	Port of Belize	Belize	0.559	Port International de Port-au-Prince	Haiti	0.591
27	GNSC Dock - Georgetown	Guyana	0.592	Port of Balboa / Gelabert Int'l	Panama	0.569	Woodbridge Bay Port / Canefield	Dominica	0.558	GNSC Dock - Georgetown	Guyana	0.581
28	Puerto Bolivar, Machala	Ecuador	0.589	Port of St. Georges	Grenada	0.568	Puerto Bolivar, Machala	Ecuador	0.550	Puerto Bolivar, Machala	Ecuador	0.577
29	Corinto / Chinandega	Nicaragua	0.589	Woodbridge Bay Port / Melville Hall	Dominica	0.566	Port of St. Georges	Grenada	0.546	Corinto / Chinandega	Nicaragua	0.575
30	Puerto Castilla / San Jose	Honduras	0.558	GNSC Dock - Georgetown	Guyana	0.559	Port International de Port-au-Prince	Haiti	0.543	Puerto Castilla / San Jose	Honduras	0.548
31	Santo Tomas de Castilla Port	Guatemala	0.548	Santo Tomas de Castilla Port	Guatemala	0.541	GNSC Dock - Georgetown	Guyana	0.538	Woodbridge Bay Port / Canefield	Dominica	0.542
32	Port of Balboa / Gelabert Int'l	Panama	0.519	Puerto Castilla / San Jose	Honduras	0.529	Santo Tomas de Castilla Port	Guatemala	0.522	Santo Tomas de Castilla Port	Guatemala	0.531
33	Woodbridge Bay Port / Canefield	Dominica	0.518	Woodbridge Bay Port / Canefield	Dominica	0.514	Puerto Castilla / San Jose	Honduras	0.511	Port of Balboa / Gelabert Int'l	Panama	0.524
34	Puerto Castilla / Goloson	Honduras	0.501	Puerto Castilla / Goloson	Honduras	0.482	Puerto Castilla / Goloson	Honduras	0.468	Puerto Castilla / Goloson	Honduras	0.494
35	Cap Haitien	Haiti	0.398	Cap Haitien	Haiti	0.389	Cap Haitien	Haiti	0.354	Cap Haitien	Haiti	0.378

Appendix E – Models (FOUO)

TRANSCOM Original Model

Due to the nature of the specific data contained within
the TRANSCOM Suitability Model, this Appendix is

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Trial 1 – Equal weighting priority for all criteria

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Trial 2 – Incorporate a “Stability” criterion based on the Failed States Index and the country; with weighting on all criteria remaining equal

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Trial 3 – Incorporate "Stability" criterion and utilize weighting priority

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Blue Dart

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Where Do We Unload the Boat?

Levying the unique strengths of strategic sealift and strategic and tactical airlift, intermodal and multimodal distribution operations conducted by United States Transportation Command (TRANSCOM) can help the Department of Defense save money while closing deployment timelines faster. Global planning for these operations requires careful analysis of port options and appropriate criteria for evaluation.

Intermodal operations have been crucial to the success of recent TRANSCOM distribution actions across the globe. Understanding the most appropriate factors to consider in seaport and airfield transloading pairs is critical to efficient and effective use of the intermodal option. TRANSCOM utilizes an analytic heuristic process (AHP) within an intermodal seaport and airfield suitability model to rank order capability ratings of transloading sites. Analysis to identify the most important criteria for evaluating intermodal transloading pairs was then used to identify the most capable seaport and airfield pairs in South America for military or humanitarian assistance/disaster relief actions supported by intermodal distribution operations.

While effective in its current form, the TRANSCOM suitability model can be more informative for planning by incorporating additional criteria for port pair reliability. Appropriately evaluating accessibility, capability, timeliness, security, and reliability as service characteristics for transport offers the best criteria for evaluating theater intermodal transloading locations. The Failed States Index, when used as measure of national stability, can be a proxy for reliability.

The criteria considered by TRANSCOM planners when developing the intermodal suitability model adequately encompasses the most important factors in port pair selection criteria. The addition of another factor, in the form of the Failed States Index, to consider nation-state stability as a measure of long-term reliability, offers further clarity for intermodal operations planning. The weighting system for rank ordering the criteria priorities within the AHP also presents very realistic and operationally effective results for seaport and airfield pairing analysis.

When considering a notional operation to support military operations or humanitarian assistance/disaster relief in a land-locked country in South America, the ports in Uruguay, Brazil, and Argentina offer the highest capability ratings with respect to the factors considered by TRANSCOM planners. The results remain the same when including considerations for geo-political stability as a measure for reliability.

Sea-air intermodal transport offers unique capabilities for the military logistician. Utilizing it effectively based on sound operational planning provides the greatest opportunity to be efficient with the limited funds available to support worldwide commitments. The use of TRANSCOM's suitability model to identify seaport and airfield pairs to conduct transloading from sea to air shipment is one piece of that planning puzzle. It is a simple but effective model that covers important and well established transportation components: accessibility, capability, time, and security. Using the existing tool generates the most capable locations to support combatant commanders' options. Incorporating factors for reliability can aid military planners in improving the model for long-term use. Military planners can confidently use the model in the future to solve similar intermodal logistical scenarios anywhere in the world.

Major Shea is a student at Advanced Studies of Air Mobility. He is a senior pilot and has flown the C-17 and C-9. His next assignment is at the Pentagon, Washington DC.

Quad Chart – Story Board

Sea-Air Intermodal Port Pair Selection Criteria In South America

Maj Phillip A. Shea

Advisor: LtCol Doral E. Sandlin, PhD

Advanced Studies of Air Mobility (ENS)

Air Force Institute of Technology

Introduction

Intermodal operations have been crucial to the success of recent TRANSCOM distribution actions across the globe. Understanding the most appropriate factors to consider in seaport and airfield transloading pairs is critical to efficient and effective use of the intermodal option. Using a review of scholarly literature, multiple runs of the TRANSCOM suitability model, and comparative assessment of various trial results, this research was used to identify the most capable seaport and airfield pairs in South America for military or humanitarian assistance/disaster relief actions.

The research also considered factors outside the TRANSCOM model to incorporate the Failed States Index's measure of national stability as a proxy for reliability.

Research Goals

- Identify the most appropriate factors to consider for selection preference of operationally effective port pairs
- Analyze the weighting factors utilized by TRANSCOM
- Identify new factors to associate with stability
- Utilize newly selected criteria to modify the TRANSCOM model, and analyze differences in port pair capability ratings

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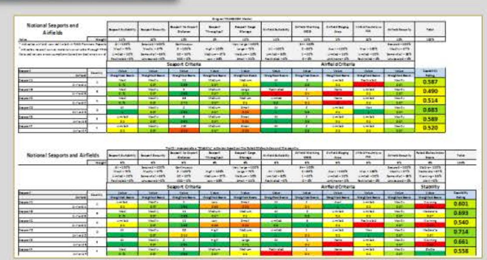
General Framework



Application

	Service Characteristic	TRANSCOM Seaport Equivalent	TRANSCOM Airfield Equivalent
1	Accessibility	Suitability	Suitability
2	Capability	Throughput, Cargo Storage	Working MOG, Staging Area
3	Transit Time	Distance to Airfield	Proximity to FOB
4	Security	Security	Security
5	Reliability	*Failed States Index*	

Motivation

- Levying the unique strengths of strategic sealift and strategic and tactical airlift, intermodal and multimodal distribution operations conducted by US TRANSCOM can help the DOD save money while closing deployment timelines faster.
- Global planning for these operations requires careful analysis of port options and appropriate criteria for evaluation.

Impacts/Contributions

- Identified the best selection criteria for analyzing seaport and airfield pairs for intermodal transloading operations

Collaboration

US Transportation Command JDPAC

Air Mobility Command A9

832d Transportation Battalion

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